

Sub-sectoral study series: Volume 02

Non-Rice Cereals, Sugarcane and Jute



Bangladesh Agricultural Research Council
New Airport Road, Farmgate, Dhaka -1215



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Foreword

Documents on agricultural sub-sector covering all areas under its broader purview are important for the policy makers, researchers and development actors of agricultural research and development (R&D). Realizing the need, Bangladesh Agricultural Research Council, as did in the past, initiated this present activity in the later part of 2009 for conducting detailed sub-sectoral studies in agriculture. The purpose was to generate background information covering areas of priority research and finally to step forward towards the development of the Agricultural Research Vision-2030 and Beyond document.

For the purpose, the agricultural sub-sector was divided as (1) Rice, (2) Non-Rice Cereals, Sugarcane and Jute (3) Horticultural Crops: Fruits, Vegetables, Spices, Flowers and Potato (4) Pulses and Oil crops (5) Land and Soil Resources Management (6) Forestry (7) Livestock (8) Fisheries (9) Irrigation and Water Management, Farm Machinery, and Post-harvest Technology (Engineering Aspects) (10) ICT and Disaster Management in Agriculture (11) Agricultural Economics, Marketing and Supply Chain Development, and (12) Food Availability and Consumption, Post-Harvest Losses, Agro-processing Technology, Food Safety and Human Nutrition. In doing so, BARC selected twelve experts of repute in the area with proven contribution in the field as the Group Leader with counterpart scientist from the council.

These 12 sub-sectoral study reports are the outcome of in-depth review of various documents related to agriculture and rural development, especially the Planning Commission reports and Five Year Plans, Poverty Reduction Strategy of the Government along with MDG, different national policy reports on agriculture, food, land use, livestock, fisheries and forestry, Vision document 2020 of BARC, Food security, quality and safety materials and available agricultural reports of WB, FAO, DFID, DANIDA and other development partners etc. In addition, series of consultations with knowledgeable quarters were made at the respective group level and at the regional and national workshops. Through review and analysis, the problems, potentials and the gap between the country's need and the present reality were identified and subsequently came up with the priority research need to address those issues.

It is to be appreciated that the agricultural research priorities have been prepared under the present socio-economic context and environmental understanding. However, with change in the situation over time and space further revision of the document would be needed. The scope and opportunities exists for gradual improvement of the priorities as we proceed to work with the suggested research priorities, gain knowledge and face new challenges.

We have now 12 supporting sub-sectoral documents on agriculture to facilitate preparation of the Vision-2030 and Beyond document as well as to undertake priority research under different themes through institutional support and for problem-solving research under SPGR and CGP to generate demand-led technology. BARC feels extremely encouraged to be able to publish these sub-sectoral documents in agriculture for circulation among the NARS institutions, universities and development partners and various other stakeholders.

As obvious, it took quite sometime to reach at this stage. But now, it appears to be worth as finally we could come up with the twelve volumes of the agricultural sub-sectoral study. These documents are to serve as a guide for undertaking future research programs and to provide direction in building the required research capacity and infrastructure of the NARS. The journey was long and the process is laborious. Identifying the best available persons to do the job, deciding on our need, providing the required guidelines, formation of technical groups within each area, getting feedback from the research, extension, input suppliers and marketing agencies, gathering problems and analyzing their magnitude and beneficiaries along with research need, organizing four regional workshops at the division level; (attended by all relevant stakeholders including farmers), presentation of the draft in different forums and finally to get the response of the participants of the 3-day national workshops all were the part of activities needed to be performed. Mr. M. Anwar Iqbal, M&E Expert of the PIU-BARC was instrumental in the whole process- from the very conceptualization to the development of these 12 sub-sectoral reports and publications. Particular thanks are due to him for his invaluable contribution. Dr. Sk. Ghulam Hussain, Member-Director (P&E) took all the pain to provide necessary guidance, making presentations at the highest level, performing as

the convenor of the priority finalization committee. Dr. Paresh Chandra Golder, CSO (P&E) coordinated the activities with utmost diligence. Much thanks are due to them. PIU-BARC and the Krishi Gobeshona Foundation (KGF) deserves special thanks for their conscientious support required to undertake the task and in organizing the workshops.

BARC expresses its heartfelt thanks and gratitude to all the group leaders, counterpart scientists of BARC, expert members of the teams and to the participants of the workshops. BARC hopes that research scientists of the NARS, extension agencies, development partners and relevant others would find these documents useful to take up agricultural R&D in order to cope with the priority and addressing emerging needs.

Dr. Wais Kabir

Executive Chairman, BARC

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Abbreviations and Acronyms

AEC	:	Agricultural technical Committee
AGDP	:	Annual Gross Domestic Product
ARI	:	Agricultural Research Institute
ASPS	:	Agricultural Sector Programme Support
BADC	:	Bangladesh Agricultural Develop Corporation
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAW	:	BARI Wheat
BER	:	Bangladesh economic Review
BJRI	:	Bangladesh Jute Research Institute
BNF	:	Biological Nitrogen Fixation
BpLB	:	Bipolaris leaf blight
BSFIC	:	Bangladesh Sugar and Food Industries Corporation
BSRI	:	Bangladesh Sugar Research Institute
CGIAR	:	Consultative Group on International Agricultural Research
CGP	:	Competitive Grants Program
CIMMYT	:	Centro Internacional de Mejoramiento de Maíz y Trigo/ International
CRI	:	Crown Root Initiation
CSO	:	Chief Scientific Officer
DAE	:	Department of Agricultural Extension
DANIDA	:	Danish Development Agency
DFID	:	Department for International Development
DG	:	Director General
DNA	:	Deoxyribonucleic acid
ESB	:	Early Shoot Borer
FAO	:	Food and Agriculture Organization
GDP	:	Gross Domestic Product
GIS	:	Geographic Information System
HYV	:	High Yielding Variety
ICARDA	:	International Center for Agricultural Research in the Dry Areas

ICRISAT	:	International Crops Research Institute for the Semi-Arid-Tropics
IDM	:	Integrated Disease Management
IPCC	:	Intergovernmental Panel on Climate Change
IPM	:	Integrated Pest Management
KGF	:	Krishi Gobeshona Foundation
M&E	:	Monitoring and Evaluation
MAS	:	Marker Assisted Selection
MD	:	Member-Director
MDG	:	Millennium Development Goal
MoA	:	Ministry of Agriculture
MoF	:	Ministry of Finance
NAP	:	National Agriculture Policy
NARS	:	National Agricultural Research System
NFP	:	National Food Policy
NGO	:	Non Government Organization
PIU	:	Project Implementation Unit
PRSP	:	Poverty Reduction Strategy Paper
PTOS	:	Power tiller Operated Seeder
R&D	:	Research and Development
RFLDC	:	Regional Fisheries and Livestock Development Component
RRMAC	:	Rural Roads and market Access Component
RSB	:	Rootstock borer
SME	:	Small and Medium Enterprise
SPGR	:	Sponsored Public Goods Research
STP	:	Spaced Transplanting
TSB	:	Top Shoot Borer
WB	:	World Bank
WMO	:	World Meteorological Organization
WRC	:	Wheat Research centre

Executive Summary

Research priority setting exercise for non-rice cereals sugarcane and jute was carried out by a 6-member group. In this exercise, general constraints to crop production and government's priority in agriculture were identified. The status of each crop, constraints (biotic, abiotic & social), research progress so far made, future research need, scope and opportunities for expansion of the crop were assessed in consultation with scientists of the concerned institutes. The findings and recommendations of the regional workshops were also discussed, analyzed and recorded. Finally research priority areas were arranged as per format supplied by PIU BARC.

In sugarcane, research priority areas were identified in 9 thematic areas. The major areas were breeding for red rot resistant, high yield, high sugar and gur content, drought, flood and salinity tolerant varieties, participatory research for yield maximization and up-scaling of technology, ratoon management, incorporation of high value crops as intercrops, quality gur making and preservation etc.

In Jute, priority research has been suggested in 14 thematic areas of crop production and jute technology. Diseases resistant (stem rot, anthracnose etc.) and high yielding variety, refinement of management practices for higher yield, improvement of soil research, improvement of fiber quality, enhancement of retting process, blending Jute for textile product are important.

In wheat priority areas has been identified in 6 thematic areas. The major ones are development of disease (BpLB and rust) resistant, high yield and heat tolerant variety for late planting, variety for saline areas, regular monitoring of diseases and insect pests, development of resource conservation technology, abiotic stress management research, improvement of research for quality seed production.

In maize 6 thematic areas were considered among which hybrid variety development with higher nutritional quality for human consumption, animal feed, saline and water logging tolerance, shifting maize cultivation to early kharif season, crop management

research for yield maximization, expansion of maize in southern belt, regular monitoring of diseases and pests etc. are important.

In all these four crops, strengthening of biotechnological research for molecular characterization of germplasms, marker assisted selection for major traits, transfer of useful genes from wild species using biotechnological tools were proposed for which lab facility and human resource development are essential.

Finally a new cereal crop, sorghum, has been suggested to introduce to counter the future climate change effect. Strengthening of international collaboration especially of technical help and genetic materials import from CIMMYT (for maize & wheat) and ICRISAT for Sorghum was emphasized. Collection of foxtail millet germplasm from home and abroad and selection of high yielding varieties and adoption of barley varieties in the southern saline belt were suggested.

1.0 Background of Work

Agriculture Sector, the backbone of Bangladesh's economy, continues to be the dominant driving force for growth and development. It is the single largest contributor to national economy and also the largest source of employment. In fact, agriculture and agro-based commodities engage about 48% of the labour force, account for about 7.34% of total export earnings and share of 21.7% (crop sector about 11.7%) of total GDP (BER, 2009). The contribution of rural non-farm sector (RNF) is 36% which is driven by agriculture. The share of agriculture and RNF together accounts for around 60% of the GDP (FAO, 2008).

Bangladesh has to face a number of challenges for achieving sustainable agriculture and food security such as rapid population increase, shrinking agricultural lands and natural resources etc. On the top of these, climatic change and natural hazards make the situation worse. The opportunity for bringing more lands under cultivation is lacking.

The projected population and the estimated food (rice+wheat) requirements for 2015, 2020 and 2030 are 156.70, 166.90, 195.53 million and 25.943, 27.632 and 32.377 million tonnes respectively (MoA 2007). So far near self-sufficiency in rice has been possible because of 8 times increase of Boro area in 2006 compared to 1972 at the cost of other crop areas. Analysis of statistics of all crops during this period showed that the areas of boro rice, potato, vegetables and maize have increased significantly, but the areas of all other crops decreased. The same trend was in production also. The gap between production and requirement is huge for these commodities. These gap need to be narrowed to face the great challenges in meeting the food and nutritional security of the country.

In view of extreme limitation of arable land, further intensification of cropping in some area may be possible with technological and policy interventions.

Considering the population increase, present and foreseeable crop production constraints, availability of natural resources, agro-ecological conditions and governments policies related to

agriculture, renewed research thrust should be given for different commodities to generate technologies on a long term basis to meet the future challenges. Twelve groups have been formed by BARC to work for this purpose. This group will work on sugarcane, jute and cereals other than rice.

2.0 Literature Review

2.1 Constraints/Issue of Crop Production

The general scenarios of crop production constraints reviewed from different literatures are briefly summarized below:

(i) *Arable Land reduction:*

Bangladesh is a land hungry country. Presently cultivable land of Bangladesh is about 8.2 million ha. But it is declining by approximately 1% due to urbanization, development of infrastructures, roads, etc. The cultivable land at this rate of decline will come down to 6.6 million ha in 2030.

(ii) *Soil fertility reduction:*

Farmers cultivate crop without returning nutrients at the rates equal to its uptake. This is causing soil fertility depletion. Increased cropping intensity (>180%) with HYV crops has led to negative balance of major nutrients (NPKS & Mg), soil organic matter (<1%) and micronutrients (Zn, B, Mo). The areas of low fertility compose about 60% of the total cultivable lands. The productivity of these soils are declining most in high and medium high lands. Loss of soil fertility during 1967-68 to 1997-98 is shown below.

Table 1. Loss of soil fertility during 1967-68 to 1997-98

Agroecological Zones	Types of Land	Loss of Soil Fertility (%)
AEZ-1	High Land	25-45
AEZ-2	High Land	10-35
AEZ-3	High Land	10-40
AEZ-9	Medium High Land	25-65
AEZ-11	High Land	20-45

Agroecological Zones	Types of Land	Loss of Soil Fertility (%)
AEZ-16	Medium High Land	15-40
AEZ-20	Medium High Land	20-40
AEZ-22	High Land	20-70
AEZ-23	High Land	10-30
AEZ-26	High Land	30-60
AEZ-28	High Land	40-65

Source: MOA Hand Book of Agril. Statistics, 2007

(iii) *Small land holdings:*

There are about 18 million farm households in Bangladesh. Of them 86.68% belong to landless, marginal and small farmers and they occupy 41.2 % of land, 11.65 % belong to medium farmers and they occupy 42.40 % and 1.67 % belong to large farmers and they occupy 16.40 % of land. Category wise distribution are as follows.

Table 2. Farm Category wise distribution and there land areas

Farm size (acre)	No. in million and (%)	Proportion of Area (%)
Landless (0.00 - 0.49)	9.33 (52.65)	4.50
Marginal (0.50-1.49)	4.19 (23.53)	18.50
Small (1.50-2.40)	1.87 (10.50)	18.20
Medium (2.50-7.49)	2.08 (11.65)	42.40
Large (>7.50)	0.30 (1.67)	16.40

Source: Science based agricultural transformation towards alleviation of hunger and poverty in Bangladesh

- (iv) Based on topography, the Bangladesh lands are classified as high (9 %), medium high (35 %), low (8 %), medium low (12 %) and very low lands (1 %) that together constitute 85 % of the total land area. The urban areas, riverine areas and homestead land constitute the remaining 15 %.
- (v) Soil pan formation: About 2.3 million ha of the basins of Tista, Ganges, Brhammaputra, Meghna and Barind tract have reported to have plough pan which restricts

proliferation of plant roots and utilization of sub-soil nutrients by the growing plants.

- (vi) Soil salinity: Of the 2.35 million ha of coastal areas (30 % of the total cultivable lands), 0.87 million ha is saline.
- (vii) Soil Acidity: Very severe form of acidification was reported in about 62,000 ha of acid sulphate soils of the coastal region along with Aluminum toxicity. Intensive acidification has also been reported in Sylhet basin, lower Atrai basin, valleys of Madhupur and Barind tract and also in north-western part of the country.
- (viii) Charland: The total charland is estimated to cover about 0.84 million ha of which about 0.2 million ha are currently cultivable. Charlands are formed due to sedimentation (24 billion tonnes annually) of various grades of sands, which degrades agril. soils. Hardly any crop grows in fresh charlands unless the soil is improved with organic matter.
- (ix) Flood and river bank erosion: Bangladesh is the terminal flood plain delta. Every year about 20-30% of the country is flooded causing serious damage to crops, lives and property. Bangladesh has 700 rivers, stretching 221555 km. About 1305 sq. km is washed away annually affecting about 1 million people with their homestead, agril. lands and crops.
- (x) Ground water depletion: Extensive extraction of groundwater especially for boro rice and intensive cropping is causing rapid drawdown of aquifer which affects irrigation of crops, especially in dry season.
- (xi) Agricultural labour Force: According to Bangladesh Labour Force Survey 2002-2003 the total labour force over 15 years of age was 44.3 million of which 51.69% was employed in Agriculture and according to 2005-06 survey out of total 47.4 million labour 48.10% is engaged in agriculture. Between these two survey periods (3 years) the number of agriculture workers decreased by 3.59%. (MoF website chapter-3).

2.2 Climate Change and its Impacts on Agriculture and Environment

Global atmospheric concentration of CO₂, Methane (CH₄) and Nitrous oxide (N₂O) have increased remarkably as a result of human activities since 1750 and now far exceeded pre-industrial value. CO₂ concentration increased from 280 ppm to 381 ppm in 2006, an increase of 36 %. CO₂ is responsible for 63% of the global warming effect. If CO₂ concentration exceeds 450 ppm, it would result in warming of 2 °C on average. CH₄ concentration contributes 18.6% of the global warming effect and its concentration has increased from about 715 ppb to 1782 ppb, an increase of 155% during the same period. N₂O contributes 6.2% of the global warming effect and it has increased from 270 ppb to 320 ppb, an increase of 19% over the same period. Agricultural N₂O and CH₄ emission are projected to increase by 35-60% and 60% respectively by 2030. The global share of average emission of Green House Gas (GHG) from agriculture is 13.5% which is due to expanding use of N fertilizer and manure to meet demand for food for rapidly growing population (WMO, 2008).

As a consequence of rise in concentration of GHGs the global Temperature will rise between 1.8⁰c to 4⁰c by the end of last decade of 21st century (IPCC, 2007). The anticipated climate change impacts in Bangladesh would be manifested in two ways in two contrasting regions such as-

- (i) The southern parts towards the sea, sea level will rise between 0.18 m to 0.79 m by the end of the century and more intense disasters including cyclones and storm surges, salinity intrusion etc. will disrupt and displace millions of people from coastal and river eroded regions, making them “environmental refugees”.
- (ii) The other part of the country in the northwestern regions will be subjected to scarcity of water leading to drought condition and aridity with less rainfall and higher temperature. For South Asia the projection of mean annual rise of temperature are 0.5⁰c to 1.2⁰c by 2020, 0.88 to 3.16⁰c by 2050 and 1.55⁰c to 5.44⁰c by 2080 depending upon the scenario of future development (IPCC, 2007). This increase will be much higher in rabi season than kharif. Tropical cyclones and tornadoes

which strike the country periodically and annually and create untold misery and loss of life and damage to property and ecosystem, are likely to increase in frequency and intensity (GED, 2008).

Change in Climatic parameters like temperature and distribution pattern and intensity of rainfall have a profound effect on agricultural production. Apart from the direct effect of temperature on plant growth it also affects precipitation, evaporation of water from soil and transpiration and all these in turn affect crop growth and production. Some of projections of climate change effect on agricultural productions are mentioned below.

- It is projected that the production of rice and wheat might drop by 8% and 32% respectively by the year 2050 (IPCC, 2007). Recent studies in India and Pakistan suggest a 5-7% decline in wheat for every degree celsius rise in temperature provided irrigation remains available in future at today's level.
- Research has shown that increasing CO₂ and temperature leads to decline in grain protein content in cereals (Hocking and Meyer, 1991; Ziska *et al.*, 1997).
- Crop-pest interaction will change significantly with climate leading to impact on pest distribution and crop losses. Changes in temperature and variability in rainfall will affect diseases of major crops (Agarwall, 2008).

Suggested Mechanisms to Cope with Climate Changes

1. Adaptation: The IPCC (2007) defines adaptation as an adjustment in natural or human systems in response to actual or expected climate stimuli or their effects which moderates harms or exploit beneficial opportunities.

There are several adaptation measures such as

- Changing planting dates
- Planting different varieties or crop species

- Development and promotion of alternative crops
- Developing new drought and heat resistant varieties
- More use of intercropping
- Improving soil drainage, no tillage etc.
- Improved crop residue and weed management
- Choose crops that require less water for moisture conservation
- More use of surface water and water harvest techniques
- Better pest and disease control (IPM-IDM etc.)

2. Mitigation: Mitigation is the technological change and substitution that reduces GHG emission and enhances sinks. About 90 % of total mitigation arises from soil carbon sequestration and about 10 % from emission reduction. The most prominent mitigation options in agriculture are

- restoration of cultivated organic soils
- Improved crop and management such as controlling emission of methane from paddy field by mid season drainage or alternate drying instead of continuous flooding, reduce nitrous oxide emission by using nitrification inhibitor like neem cake etc.

Mitigation alone is however, not enough and will not be felt before the second half of the century. Global warming is already underway and adaptation strategies are now a matter of urgency, especially for the most vulnerable poor countries.

2.3 National Policies and Programmes

2.3.1 Poverty Reduction Strategy Papers (PRSP 2005)

According to the World Bank report 53% of the rural populations of Bangladesh are classified as poor and 85% of the total numbers of the poor live in rural areas and majority of them are still dependent for income and livelihood on agriculture.

According to PRSP the poverty level to be reduced to half (26.5%) by 2015 for achieving the MDG. The government has identified agriculture and rural development as the topmost priority sector for rapid poverty reduction. With about 21.71% of GDP contributed by

agriculture and another 36% by rural non-farm sector, the rural economy as a whole contributes more than 60% of the total GDP. Agriculture sector generates two-third of total employment, contributes 7.34% of total export earning and provides food security to the increasing population.

To achieve the PRSP goal the agriculture growth rate will be required at least 4% and in non-farm sector 7% (World Bank: Bangladesh Priorities for agriculture and rural development). The current growth rate (2007-2008) in agriculture is 3.61 and other services is 6.69 (MoF, 2009).

Agriculture and the rural economy are recognized as the key driver of propoor growth strategy. The Govt. policy to support the strategy focuses on the following five issues:-

- Increase productivity of major crops (i.e. cereals)
- Diversification of high value non-cereals crops (i.e. fruits, vegetables, cash crop)
- Development of non-crop agriculture (fishery, poultry, livestock, etc.)
- Promotion of rural non-farm activities (construction, transport, etc.)
- Development of Agri-business services and market promotion

One comprehensive review has shown that a one percent increase in yield reduces the number below 1\$/day poverty by 6.25 million, 95% of those are in Africa and Asia (Thirtle *et al.* 2002, World Bank Bangladesh).

The overall policy of the Govt. is to create an enabling environment and play a supportive role in transforming agriculture and the rural economy as a whole in poverty reduction.

2.3.2 National Agriculture Policy (June 2009)

The National Agriculture Policy (NAP) aims at creating an enabling environment for sustainable growth of agriculture for reducing poverty and ensuring food security through increased crop production and employment opportunity as envisaged in PRSP, MDGs and SDGs.

The specific objections are to

- (i) developing and harnessing improved technologies through Research & Training
- (ii) increasing productivity and generating income and employment by transferring appropriate technologies and management inputs.
- (iii) promoting competitiveness through commercialization of agriculture
- (iv) establish a self-reliant and sustainable agriculture adaptive to climate change and farmer's needs.

Research and Development (R&D)

Agricultural Research needs a paradigm shift from a supply-driven to a demand driven approach. This will need a change in focus from production level to production efficiency, productivity and profitability. Besides equity, employment, environmental sustainability, nutrition, food quality, trade, etc. have new areas of concern to maintain food security to continue.

Research focus and Areas

The research activities will focus on intensification, diversification and whole farm activities in agriculture - as outlined in the NAP are-

- Post production technologies, value addition, high value crops, agribusiness management and trades.
- Emerging issues like biotechnology, hybrid, climate change, disaster and stress including flood, drought, cyclone, salinity, upland/hills, deep water crop management, organic farming, rainfed agriculture.
- Cross cutting issues - sustainability of production system, poverty alleviation and livelihood improvement, household food security, off-farm income generation and rural development.

Natural Resource Management Research

- Development of eco-friendly technology and sustainable land and water management for different agro-ecological zones and regions.
- On weather forecast, climate change and disaster management.

- Conservation and effective use of life support system of soils, water, flora, fauna and atmosphere.
- Collect, conserve and utilize genetic resources.

Mechanization - Although primary use of machinery has started in tilling, weeding, threshing, but more appropriate agri-machinery will be required for planting, weeding, harvesting, processing etc. as the draft power and agri-labour are gradually decreasing. Research and development in this sector needs to be augmented.

Apart from these the policy also addresses the problems of improving lands, water and labour productivity, privatization for ensuring supply of inputs (including seeds), technology transfer and training etc. These interventions are currently being made through many development projects and programmes.

2.3.3 *The National Food Policy (NFP) 2006*

The NFP declares a comprehensive multi-sector approach to attain all aspects of food security as follows:

- Technological security to ensure yield improvement coupled with production and safety.
- To achieve greater efficiency of domestic agriculture and enhanced availability of food for all.
- Sustain increased incomes of the poor and the distressed to enhance their access to food.
- Ecological security to provide the basic life support system upon which sustained agricultural improvement depends.

Above all in accordance with the article 15(a) of the country's constitution, Bangladesh's top priority is to ensure food security and food safety at national, household and individual level so that all people have access to adequate food safety at all times.

2.3.4 *Agriculture Sector Review and Actionable Policy Brief*

Agricultural Research in 1970s started from a low technology base and it was relatively easy to make quick technological breakthrough from a low base with adequate facilities and IARCs support. That stage is over. HYV technology has now reached the peak of its potential. Further breakthrough in yield is not going to be easy.

Moreover, second generation problems surfaced out such as nutrient mining, ground water depletion, environmental pollution etc. (already discussed). At the same time cultivated land is shrinking and population is increasing.

In this scenario the priority research in general are to be to address the second generation problems for sustaining the gains in crop production and further improving productivity to meet the food demand for increasing population under a range of agro-ecological conditions by developing new varieties and methods to-

- raise yield and increase production efficiency in both irrigated and rainfed areas.
- provide greater tolerance to stress conditions such as prevailing and future diseases and insect pest, drought, flood, adverse soil condition.
- improve soil health and productivity.
- meet the challenges of climate change effect.
- introduce high yielding, stress tolerant alternative food crops for food security for special circumstances and regions.

2.3.5 National Land Use Policy 2001

The salient features of the National Land Use Policy are to -

- Halt the present alarming rate of conversion of agricultural land to non-agricultural purposes.
- Prepare guidelines for maximum land utilization based on agro-ecological characteristics.
- Reduce environment pollution and degradation of land, water and air and promote environment friendly activities in agricultural development.

2.3.6 Agricultural Sector Programme Support (ASPS-II)

The main goal of ASPS (II) is to support the government of Bangladesh implement the PRSP. The agriculture sector is an important tool to reach this goal as it directly reaches the poor in the rural areas, providing both food and cash at the same time. The agricultural production should focus on a diversified and more effective production in the poor rural areas. The development objective of ASPS-II will focus on promotion of food production

and diversification for improved living conditions of the poor, marginal and small farmer households through enhanced, integrated and sustainable agricultural productivity. It will provide supports through Agricultural Extension Component (AEC), Regional Fisheries and Livestock Development Component (RFLDC), Rural Roads and market Access Component (ARMAC) and Strengthening Policy Planning.

2.3.7 World Bank Priorities for Agriculture and Rural Development

Priority areas for the world bank's support are

- Increasing agricultural productivity, diversification and value addition through a dynamic and responsive agricultural research and extension to accelerate the transition from subsistence to commercial farming, export promotion and bridging yield gap.
- Enabling rural business environment for small and medium enterprise (SME) and agro-business development.
- Improving factor markets, access to assets and natural resource management.
- Strengthening rural institutions and livelihood support by improving roads, electricity, communication, water, health and education and creating and strengthening local organization like farmers' association, women group etc.

Summary of the Reviewed Literatures

Reviewing the literatures related to crop production the major issues and constraints surfaced out are as follows:

- Cultivable land is shrinking, about 6.5-7.0 million ha land may be available against the existing 8.2 million ha in 2030
- Small land holdings- landless, marginal and small households (86.68 %) occupy 41.20 % of land, medium class (11.65 %) occupy 42.40%, and large group (1.67 %) are the owner of 16.40 % land of the country
- Based on topography Bangladesh's lands are classified as 29 % high, 35 % medium high, 12 % medium low, 8 % low and about 1 % very low
- Cropping intensity is high, already >180%

- Huge yield gap between on-station and on-farm.
- Soil fertility is reducing, organic matter, macro and micro nutrient deficiency are emerging as major constraints.
- Salinity (0.87 million ha) in southern belt, which is almost a single cropped area.
- Soil acidity is also a problem of a significant area.
- Charlands occupies about 0.52 million ha of which only 0.2 million is currently cultivable.
- Flood is a common problem and on an average about 20-30% of the country is flood affected every year (some years 40%), causing damage to crops, life and property
- Ground water depletion is occurring and rapid draw down of water table is causing irrigation problem in many areas
- Number of agriculture workers is showing a decreasing trend
- Climate change effects-
 - temperature may rise between 1.8 °C to 4 °C by the end of this century
 - sea level rise between 0.18 m to 0.79 m by the end of this century.
 - Northern Bangladesh will face scarcity of water and drought
 - Natural calamities and disasters will increase
 - Rice and wheat yield may drop by 8% and 32% respectively by 2050
 - Surge of crop-pest (disease & insects) incidence and virulence may occur in major crops.

Summary of the Government. Policy and Programmes Related to Agriculture

Summary of almost all the Govt. policy related to agriculture and food security are centered around the following major issues –

- Poverty reduction - According to PRSP the poverty level to be reduced to half (26.5%) by 2015 and the government has identified agriculture and rural development as the topmost priority sector for rapid poverty reduction. To achieve this, agriculture growth rate will be required at least 4% and non-farm sector growth rate 7% against the current growth rate of 3.6% and 6.69% respectively.

- The National Agricultural Policy (NAP) broadly aims at creating an enabling environment for sustainable growth of agriculture for reducing poverty and ensuring food security through increased crop production and employment opportunity as envisaged in PRSP, MDGs and SDGs.

Some of the important researchable areas indicated in the policy are:

- Productivity improvement, intensification, diversification and whole farm activities in agriculture for income generation and rural development
 - Emerging issues like biotechnology, hybrid development, climate change and disaster and stress management
 - Natural resource management such as development of ecofriendly technology for sustainable land and water management, weather forecasting, GIS, etc.
 - Collection, conservation and utilization of genetic resources
 - Post production technology, value addition, high value crops, agribusiness management and trades
 - Mechanization of agricultural operations.
- The National Food Policy's top priority is to ensure food security and food safety at national, household and individual level at all times. To achieve the objective emphasis has been given to increase domestic agricultural production through improved technologies which will also ensure ecological security to sustain production and increase incomes of the poor to enhance their access to food.
 - The donor's supports (ASPS-II, WB) are also in favour of implementing PRSP through increased agricultural production, diversification, value addition and market chain development for income generation.

From the two review summaries the research priority in general, should focus on the following aspects depending on the crop

- Development of further high yielding varieties including hybrids with greater tolerance to diseases and pests, increased adaptation to heat and water stress (drought &

water logging), salinity and rich in nutrition or desired economic quality.

- Natural resource management research particularly for improving soil health and productivity, water conservation and sustain natural ecosystem.
- Farmers' participatory research should be strengthen to reduce yield gaps and technology adoption.
- Mechanization research for developing appropriate farm machineries.
- Disease and pest management research for continuous monitoring of new races, virulence and control mechanism.
- Collection, conservation and utilization of genetic resources.
- Crop diversification
- Biotechnological research
- Post production technology, value addition, agribusiness and trades to achieve PRSP goal.
- Address climate change issues through adaptation, mitigation and introduction of new crop species to meet the challenges.

In the light of the above points the specific priorities of individual crops are discussed in the following sections after reviewing the status of the crop, constraints, progress so far made against the constraints and future research priorities in different thematic areas (disciplines).

3.0 Work Plan and Main Activities

- Reviewed the literatures and documents related to agricultural constraints, government policies, climate change issues, government's economic reviews, objectives of donor's support etc. and based on these directions to which the agricultural research to be directed in future was synthesized.
- Reviewed the status of individual commodity, its constraints, research progress made so far, and identified the future need in thematic areas and prioritized.

3.1 Approach and Methodology

- The group leader collected the necessary documents, literature and reviewed.
- The group leader and the member-secretary of the group identified a competent scientist for each crop from the concerned institute in consultation with the DG/Director research of the Institute.
- At the beginning a consultation meeting was held with the group member, the task and objectives was explained to them and finally a format was provided to each member for developing the draft report.
- The individual scientists then developed the draft report in consultation with the concerned scientists of various disciplines of his crop.
- The draft was initially finalized after several discussion meetings of the group members and in the light of 4 regional workshops recommendations (*Annexure-I*).

The draft was presented in the central workshop organized by BARC where experienced retired scientists, NARS scientists, university professors, DAE, BADC and NGO representatives participated. Their comments and suggestions (*Annexure-I*) were incorporated and the report was finalized.

3.2 Sub-sectoral Studies

The sub-sectors sugarcane, jute, cereals other than rice was analysed on the following heads:

1. Introduction
2. Production trends and yield gap analysis
3. Constrains (biotic, abiotic, social)
4. Research progress made to address the constraints
5. Demand of the commodity in 2015, 2020 and 2030
 - Developed research priority matrix (short, medium, long)
6. Identified opportunities for vertical and/or horizontal expansion
7. Recommendations and conclusion.

4.0 Sub-sectoral Analysis and Priority Matrix

4.1 Sugarcane

4.1.1 Introduction

Sugarcane is an important food-cum-cash-cum-industrial crop. It covers 2.05 percent of the total cultivable land. More than 0.60 million farm families are dependent on sugarcane cultivation for their subsistence. It is the principal raw material of sugar industry, the major source of white sugar and jaggary (*gur*) production in Bangladesh. Currently, on an average sugarcane is grown in 0.16 million hectare of land of which almost 50% area is in the sugar mills zone, and the remaining 50% is in the non-mills zone, where sugarcane is mostly diverted for jaggary and juice production. Presently, 15 sugar mills are in operation under Bangladesh Sugar and Food Industries Corporation (BSFIC) with a capacity of 0.21 million tonnes of sugar production per year (BSFIC, 2008). These industries are providing employment for nearly 16000 persons (BSFIC, 2005). Management factors responsible for low yield and low sugar recovery percentage and high sugar price are high processing loss, excessive manpower engagement in the factory, low capacity utilization and higher production cost in comparison to the other sugar countries; environmental factors as weather and sunshine are also not congenial for high sugar recovery.

In Bangladesh, per hectare yield is about 40 tonne, but it is about 70 t in other sugar producing countries. Recovery per cent in Bangladesh is 7.0 to 8.5 only, but it is 8.5 to 11.0 in other countries (EU, Brazil, Australia, Thailand, Mauritius). The neighboring India and Pakistan have also the higher recovery than Bangladesh. This low yield and recovery caused mainly by management factors in production level. Environmental factors like weather of Bangladesh and sunshine period are not also favorable for high recoverable sugar. Although now sugar industry is in losing concern but still the sugarcane crop is contributing 0.67 percent to the national GDP. The highest contribution comes from jaggary sector (0.39%) followed by sugar (0.15%), chewing and juice (0.04%), seed (0.03%), cattle feed and fuel (0.03%) and by-product (0.03%) respectively. It is still an insurance crop under rainfed condition as well as water logged situation in northern and western regions where most of the sugarcane are cultivated.

During the last ten years (1999-00 to 2008-09) sugarcane was grown on an average in 160.54 thousand (0.16 million) hectare of land producing 6564.91 thousand (6.5 million) tonne of sugarcane (Table 3) It is revealed from the table that in 1999-00 sugarcane was grown in 170.45 thousand (0.17 million) hectares of land but in 2008-09 it came down to 153.74 thousand (0.15 million) hectares. Growth rate (1999-00 to 2008-09) of sugarcane area and production in Bangladesh was -0.012 and -0.002 percent and in mill zone it was -0.007 and 0.000 and in non mill zone it was -0.015 and -0.007 percent respectively which indicated that there is a declining trend in area and production during last ten years due to various reasons.

Table 3. Trend and growth rate of sugarcane area and production in Bangladesh (1999-00 to 2008-09)

Crushing season	Bangladesh	Mill zone		Non mill zone		
	Total sugarcane cultivation ('000 ha)	Total product ion ('000 t)	Total sugarcane cultivation ('000 ha)	Total product ion ('000 t)	Total sugarcane cultivation ('000 ha)	Total product ion ('000 t)
1999-00	170.45	6910.00	86.4	3526.5	84.05	3383.5
2000-01	168.83	6742.00	74.87	3361.87	93.96	3380.13
2001-02	162.75	6502.00	88.27	4475.99	74.48	2026.01
2002-03	165.99	6838.00	105.42	4595.27	60.57	2242.73
2003-04	163.56	6484.00	84.87	3948.24	78.69	2535.76
2004-05	157.09	6423.00	78.18	3516.97	78.91	2906.03
2005-06	152.63	5511.00	75.43	3717.3	77.20	1793.7
2006-07	150.00	5770.00	83.6	4112.66	66.40	1657.34
2007-08	160.40	7371.14	86.4	4051.14	74.00	3320.00
2008-09	153.74	7097.92	78.74	3497.92	75.00	3600.00
Mean	160.54	6564.91	84.22	3880.39	76.33	2684.52
Growth rate (%)	-0.012	-0.002	-0.007	0.000	-0.015	-0.007

Source: BSFIC, BSRI, DAE Reports (1999-00 to 2008-09)

Sugarcane is not only used for sugar and jaggary production but also used for seed and chewing purposes. If we take the average of last 10 years production, out of 6.56 Mt of cane 1914.28 (29.16 %) thousand tonnes was used for sugar production, 3724.38 (56.73 %)

thousand tonne was used for jaggary production and 926.25 (14.11 %) thousand metric tonne was used for seed and chewing purposes respectively (Table 4).

Table 4. Sugarcane production and its utilization in Bangladesh (1999-00 to 2008-09)

Crushing Season	Sugarcane production ('000 m t)	Sugarcane used for sugar production ('000 m t)	Sugarcane used for jaggary production ('000 m t)	Sugarcane Used for seed and chewing ('000 m t)
1999-00	6910.00	1612.32	4330.28	967.40
2000-01	6742.00	1369.03	4429.09	943.88
2001-02	6502.00	2811.12	2866.6	924.28
2002-03	6838.00	2633.43	3247.25	957.32
2003-04	6484.00	1642.51	3933.73	907.76
2004-05	6423.00	1414.49	4109.29	899.22
2005-06	5511.00	1853.18	2886.28	771.54
2006-07	5770.00	2335.04	2627.16	807.80
2007-08	7371.14	2287.53	4029.54	1054.07
2008-09	7097.92	1184.11	4884.61	1029.20
Mean	6564.91	1914.28	3724.38	926.25
	100 %	(29.26%)	(56.73%)	(14.11%)

Source: BSFIC, BSRI, DAE Report (1999-00 to 2008-09)

Sugarcane in non mill zone is used for jaggary production. In Bangladesh, total production of sugar and jaggary was 136.80 thousand (0.136 million) and 372.74 thousand (0.372) million tonnes and the recovery of sugar and jaggary was 7.18 and 10.30 percent respectively. Although sugar industries are losing concern but jaggary production is profitable because cost of production is lower than sugar production.

Trend of Area and Production

The area, production of cane, production of sugar and *gur* from 1990-91 to 2008-09 are presented in Table 5. It appears from the table that total sugar+*gur* produced in 1990-91 was 678000 t which was only 47.56% of total demand. However, the production continuously declined to 404000 t in 2008-09 which was 21.29 % of total demand. If we analyze the long term area and production (cane) it is observed in Figure 1 that the average area from 1972-1985 was 150000 ha, 1986-1996 was 179000 ha and 1997-2009 was 163000 ha. Similarly the production of cane of these periods were 6495,428 t,

7211182 t and 6547000 t and yields were 43.21 t/ha, 40.34 t/ha and 40.45 t/ha. Which means the area and production increased during 1986-96 but declined gradually afterwards. However, the yield was a bit higher in the 1st decade (43.21) but it fluctuated around 40 t/ha later. The growth rates of area and production for the last 10 years were -0.012 and -0.002 respectively (Table 3).

Table 5. Trend in sugarcane area and production of sugarcane, sugar and gur of Bangladesh

Crushing Season	Sugarcane		Sugar production ('000 mt)	Gur production ('000 mt)	Total sugar/gur production ('000 mt)	% of demand
	Area ('000 ha)	Production ('000 mt)				
1990-91	191.09	7682.00	246.00	432.00	678.00	47.56
1991-92	187.45	7446.00	195.00	482.00	677.00	46.75
1992-93	184.62	7507.00	187.00	415.00	602.00	41.00
1993-94	180.97	7111.00	221.00	334.00	555.00	36.29
1994-95	180.16	7446.00	270.00	285.00	555.00	35.59
1995-96	174.49	7165.00	184.00	371.00	555.00	35.00
1996-97	175.71	7521.00	135.00	463.00	598.00	37.00
1997-98	175.30	7379.00	166.00	415.00	581.00	35.27
1998-99	174.09	6951.00	153.00	359.00	512.00	30.00
1999-00	170.45	6910.00	123.00	427.00	550.00	32.18
2000-01	168.85	6742.00	98.00	436.00	534.00	31.12
2001-02	162.75	6502.00	205.00	306.00	511.00	29.55
2002-03	165.99	6838.00	177.00	322.00	499.00	28.64
2003-04	163.56	6484.00	119.00	371.00	490.00	28.00
2004-05	157.08	6423.00	107.00	462.00	569.00	32.00
2005-06	152.63	5511.00	133.00	333.00	466.00	25.83
2006-07	150.00	5770.00	162.00	310.00	472.00	25.82
2007-08	130.00	4984.00	164.00	299.00	463.00	24.76
2008-09	153.74	7098.00	80.00	324.00	404.00	21.29
Average of Last 10 yrs	157.50	6326	136.80	359.00	495.8	27.8

Source: BSS, BSFIC, DAE

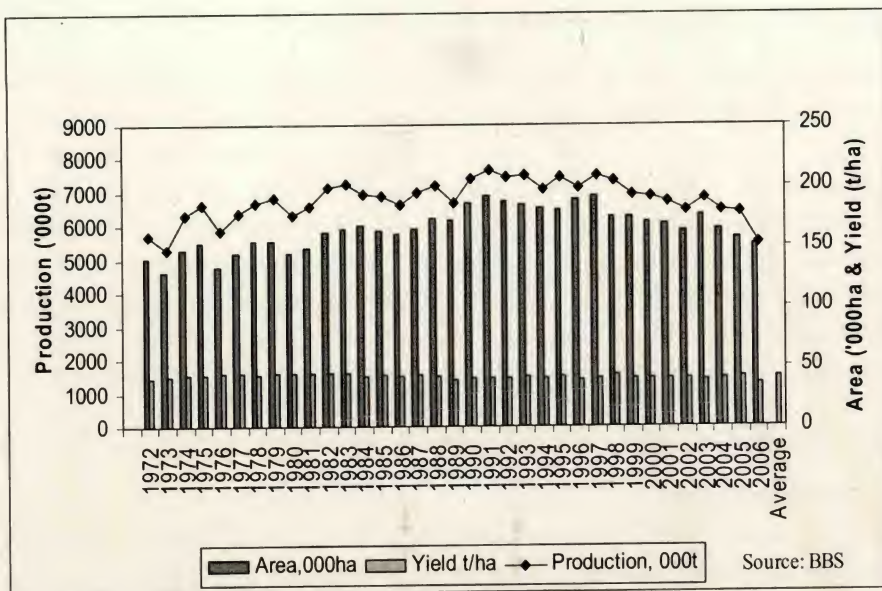


Figure 1 Area, production and yield of sugarcane

4.1.2 Constraints

A. Biotic Constraints

(i) Dearth of appropriate genetic resources

Limited number of germplasm and poor genetic base for hybridization. Lack of natural flowering and synchronization in germplasm.

At BSRI, about 1000 sugarcane germplasms are being maintained in the germplasm bank of which about 75% germplasms do not flower at all. Flowering is the prerequisite for hybridization process. Due to non-flowering of the desirable germplasm, it is not possible to make the desirable crosses among them. Moreover, among the flowering ones, some are flowering early and some are late. So, expected results are not achieved. The species of *Saccharum spontaneum* has so many undesirable traits such as high fibre, less juice and sugar, pipe, pith but has some good traits like high tillering, drought and disease resistance etc. But these traits could not be used for their irregular and untimely flowering (Sept - Oct. and incompatibility of crossing with *S. officinarum* for which biotechnological approach will be needed.

(ii) Lack of high yield stress resistant variety

Although about 40 varieties have been released by BSRI but none are absolutely resistant to major stresses like red rot, smut disease, flood or drought, major insect pests etc. Moreover, a variety degenerates within a few years due to biotic or abiotic stress. Therefore, variety development for different traits is a continuous process. At the same time it must be a coordinated approach where other disciplines such as pathology, entomology, physiology, sugar chemistry and biotechnology should also play major roles in screening the breeding materials in selecting appropriate genotypes.

(iii) Diseases

Red rot disease

Red rot is the most serious disease of sugarcane in Bangladesh. The disease causes extensive losses in yield and quality. The losses may go up to 80-100% when occurs in epidemic form. Due to red rot disease many high yielding and high sugar variety have been dropped from cultivation. Red rot pathogen *Colletotrichum falcatum* possesses different pathotypes. New virulent races/biotypes may be developed due to change of environment. As no satisfactory control measure is available, therefore, use of resistant variety is the most effective means to combat the red rot menace.

Smut disease

Smut is another important diseases of sugarcane not only in Bangladesh but also in other sugarcane growing countries of the world. The loss may go up to 100% when naturally infected setts are planted. Yield loss ranged from 39-56% in plant cane and 52-73% in ratoon cane. Furthermore, brix, sucrose and purity are adversely affected due to smut infection. Chemical control and agronomic practices are not effective to reduce the disease. However, substitution of susceptible varieties by resistant ones is one of the most successful and reliable options to control the disease.

Wilt disease

Wilt is one of the baffling diseases of sugarcane and found to be of considerable importance. The disease has a wide occurrence in the cane growing areas. It reduces the germination of seed materials, dries up young shoots and subsequently the cane stalks become wilted. The pathogen is soil borne and chemical control is not

effective against the disease. Therefore, use of resistant varieties is one of the most effective methods to curb the disease.

White leaf disease

White leaf disease of sugarcane can cause severe yield losses, particularly when the planting material is obtained from infected sources or when disease transmission occurs during the early stage of plant growth. No chemical treatment is available to control the disease. Scope of identification of resistant variety is limited due to lack of screening technique. However, use of clean seed is the most effective way to control the disease.

Pineapple disease

Sugarcane crop is vulnerable to a number of diseases of which pineapple disease is an important one. Normally, the disease is noticed severely in heavy and ill drained soils. It causes considerable losses in germination of setts. The disease can reduce sett germination up to 47% which subsequently hamper the yield of cane. The yield reduction due to this disease may be as high as 31-35%. It can be controlled by sett treatment with fungicides to some extent. The use of resistant varieties is the most judicious strategy to escape the disease.

(iv) Insect Pest

So far, 70 species of insects and mites have been identified as pests of sugarcane which include borers, suckers, defoliators and underground insects. About 50 natural enemies of pests have been identified beneficial to the crop. Considerable yield losses which are estimated to be around 20% in cane yield and 15% in sugar recovery have been reported (Avasthy, 1983). However, 10 species of insects are major and research programme is mainly oriented with those viz. top shoot borer, stem borers, rootstock borer, white grubs, termites, early shoot borer, pyrilla leaf hopper, black leaf hopper, scale insect and mealy bug which are persistent pests and cause considerable damage to the crop and thus of economic importance.

The economic importance of most important pests are briefly discussed below:

Top shoot borer

Top shoot borer (TSB) is one of the major pests of sugarcane. Top shoot borer can cause damage showing the infestation level from 10-100% (Miah *et al*, 1980) and yield loss from 20-50.17% (Khalequzzaman and Mannan, 1980). Mechanical control like cutting of infested plant along with larvae and egg mass collection are very effective measure in controlling sugarcane top shoot borer. Chemical control is very effective to control the pest.

Stem borer

Stem borer is the most destructive pest of sugarcane in Bangladesh. Maximum weight losses of 28.73, 18.64 and 18.01% and sucrose losses of 9.74, 11.21 and 15.93% were estimated in Isd 16, Isd 21 and Isd 30 variety respectively having more than three bores in infested cane.

Mechanical control like cutting of primary infested plant is very effective measure in controlling sugarcane stem borer. Chemical control is very effective to control the pest. *Trichogramma chilonis* Ishii release @ 50,000/ha/wk from May to September is recommended to control stem borer.

Rootstock borer

Rootstock borer (RSB) is one of the major pests of sugarcane. Its abundance is more in sandy soils. Higher infestation is observed in northern part of Bangladesh like Dinajpur, Thakurgaon and Panchagar district. Rootstock borer can cause damage showing infestation level upto 68% recording a loss in cane weight up to 8.55% (Miah *et al*, 1986).

Mechanical and chemical controls are used to control the pests. Stubble burning after harvest reduces RSB infestation in the following season. Water logging for 2-3 days reduces RSB infestation. Chemical control is very effective to control the pest.

White grubs

There are 17 species of white grubs damaging sugarcane in Bangladesh. Among soil pests white grubs play considerable role in damaging canes. Due to white grubs 20-100% infestation is observed in the field (Miah *et al*, 1983). Sugarcane production may decrease upto 34-100% due to attack of white grubs.

Mechanical and chemical control are effective to control the pest. Water logging for 2-3 days reduces white grub population.

Termites

There are 5 species of termites attacking sugarcane in Bangladesh. Among soil pests termites play considerable role in damaging canes. Termite infestation is observed both in setts (bud) and in standing canes. In the field 1-60% infestation is observed which may cause 1-33% yield loss and 1-5% recovery loss. Cultural, mechanical and chemical control are effective to control sugarcane termites.

B. Abiotic constraints

(1) Crop management

With optimum management about 70t/ha yield of cane is obtained in the farmers' field against the national average of about 40t/ha. The reasons of low yields are related to various agronomical practices, soil factors, ecological factors and socio economic factors.

These are briefly discussed below:

(i) Late plantation

Optimum planting time of sugarcane is October to November. But 80% of total sugarcane is planted during December to February which is the coldest time of the year. It not only affects germination due to low temperature as well as moisture stress in the soil but also reduces crop duration for full growth. As a result their yield is low.

(ii) Low plant population

Yield of sugarcane depends on number of millable canes produced and weight of individual cane stalk which is positively correlated to agronomic management. About 100,000 - 120,000 no. of millable cane/ha is optimum for about 90 t/ha yield of sugarcane. Besides, it requires more seeds and therefore, the initial cost is higher for new or improved seed which many farmers can't afford and they use their low quality own seeds resulting poor germination with low number of mother plants.

(2) Soil Factors

(i) Low soil fertility

Bangladesh soil is in general low in soil fertility and organic matter. Due to continuous monocropping and application of only inorganic fertilizer the sugarcane soils are quickly becoming unfertile. Nutrient replenishment through recycling of farm and factory wastes along with inorganic fertilizers in soil is indispensable for sustainable crop production.

(ii) Biological nitrogen fixation (BNF) in sugarcane

Nitrogen is the most limiting nutrient for increasing sugarcane productivity. Biological nitrogen fixation (BNF) helps in improving soil fertility by using nitrogen, which is in abundance in the atmosphere (79%). It is reported that several Brazilian sugarcane varieties are capable of obtaining over 60% of their nitrogen ($>150 \text{ kg N ha}^{-1} \text{ year}^{-1}$) through BNF from atmosphere (Boddey *et al.*, 1987). Therefore, an attempt is necessary to undertake a comprehensive study to develop bio-fertilizer for sugarcane using BNF-technology with appropriate bacteria that can make a break through in sustainable sugarcane production in Bangladesh.

(iii) Increasing soil salinity in coastal area

Saline soils have a high content of soluble salts. The EC value of saturated extract is more than 4 ds/m at 25°C, ESP value is less than 15 and the pH value is below 8.5. The saline soils exist in southern parts of Bangladesh which is a great constraints for crop growth including sugarcane.

(iv) Soil acidity

Soil acidity is the key factor of nutrient availability in soil and crop productivity. Due to rise of soil acidity, most of the major nutrient elements become unavailable to crop plants and the element like phosphorus undergoes fixation in soil, and also creates Fe and Al toxicity for the plants. Increased soil acidity impaired crop growth and declined crop production including sugarcane.

(3) Ecological factors

Flood, Waterlog and Drought

In Bangladesh, the important reasons of low yield of sugarcane is water-logging, flood, drought and salinity problem. About 25% of sugarcane is grown in low lying areas and sugarcane varieties being cultivated can not withstand under water-logging condition. As a result higher yield can not be achieved. Because sugarcane developed for high and medium high land do not grow well in these conditions. In Bangladesh about 80% of the sugarcane field is rainfed resulting in low yield. Sugarcane needs 1200 to 1500 mm of water either from rainfall or irrigation. The quantity of rainfall and time of rainfall are very much un-certain. Moreover, sugarcane planting season (November to February) is usually dry and irrigation is essentially required at this time to ensure better germination/establishment of setts/settlings and higher yield. In drought prone areas of Bangladesh, yield of sugarcane is low due to lack of drought tolerant varieties. To extend sugarcane cultivation in marginal land and drought prone areas development/screening of drought tolerant varieties is important.

Gur related constraints:

(i) Low quality Gur

A variety suitable for sugar production may not be equally suitable for *gur* production. In some areas of Bangladesh early *gur* making starts from August. Due to lack of suitable *gur* making early maturing variety, *gur* makers are manufacturing *gur* from old indigenous/degenerated varieties. As a result, *gur* production is low and quality of *gur* is poor and they are adding chemical clarificants to improve the colour of *gur*. Chemical clarificants are hazardous for human health. Therefore, it is important to screen sugarcane varieties / clones to produce good quality *gur*.

(ii) Granular Gur production

Gur is generally prepared in two forms (a) solid and (b) semi solid. Major production is in the solid form. Semi solid *gur* deteriorates faster than solid *gur* due to higher moisture content. Solid *gur* also deteriorates during monsoon due to absorption of atmospheric moisture. During storage condition, *gur* becomes soft, inversion and

fermentation take place. At the present situation granular *gur* production may be the most effective step for preservation and consumption of *gur* throughout the year. At the high humidity period, granular *gur* retain its quality. It is important to standardize granular *gur* processing method, suitable packaging materials & preservation system. Therefore, manufacture of *gur* in granular form is a suitable technique for preservation throughout the year for consumption.

(iii) Juice clarification

The *gur* manufacturers are using chemical clarificant, Hydrose, to clarify cane juice for making *gur*, which is harmful for human health. It is reported that prolonged intake of hydrose added *gur* can create bowel irritation, chronic dysentery and gastrourinal troubles. Use of plant extract clarificant is one of the ways to reduce this problem.

(iv) High efficient power crusher & improved pan & *chula*

Crushing of cane is a major problem in Bangladesh. Most of our farmers crushed their cane using conventional method in which they lose 30% sugar mixed with bagase. Use of improved pan and *chula* also a crying need in present perspective of Bangladesh. By using an improved *chula* (oven) we can save fuel.

Socio-economic constraints:

(i) Competition of sugarcane with high value short duration crops

Sugarcane is a long duration field crop which requires more than one year from planting to maturity. So farmers like to grow short duration high value crops rather than sugarcane. Intercropping with suitable winter vegetables, pulses and oil crops with sugarcane can be an option for increased income and sustainable sugarcane production.

(ii) Labour scarcity

Sugarcane is a labour intensive crops and labour availability is decreasing gradually. Therefore, development of agricultural implements for partial mechanization is essential for economic

sugarcane production. The mechanization ensures reduction of drudgery associated with various farm operations and also economizes the utilization of inputs and thereby harnessing the potential of available resources. Agricultural mechanization increase land productivity through timeliness of operation, ensure land utilization, increase labour productivity and also provides a means for lessening the drudgery of human labour.

(iii) Low price of sugarcane in comparison to other competing crops and production cost

Price of sugar is low compared to other agro processing crops. Price change of sugar, rice, edible oil and beef from the period of 1990-91 to 2006-07 was 35.48, 71.21, 41.74 and 206.12 percent respectively. It implies that sugarcane price change was lower than other agro-processing crops.

4.1.3 Research Progress

Discipline	Technology generated															
a. Genetic resource	A total of 1004 accession of sugarcane germplasm have been collected and conserved in the Gene Bank (field) and gradually characterized and evaluated for different traits. Number of accessions are as follows: <table><tr><td>A)</td><td><i>S. officinarum</i></td><td>: 968</td></tr><tr><td></td><td>a) Imported</td><td>: 352</td></tr><tr><td></td><td>b) Local Collection</td><td>: 158</td></tr><tr><td></td><td>c) Institute bred</td><td>: 458</td></tr><tr><td>B)</td><td><i>S. spontaneum</i></td><td>: 36</td></tr></table> i. The imported genotypes are mainly high yielding and high sucrose content but most of them are red rot susceptible ii. The locally collected genotypes are normally widely adapted and red rot tolerant but comparatively low in yield and sucrose content. iii. The institute bred genotypes are generally intermediate in yield and sucrose content and moderately tolerant to red rot disease. iv. About 75% of the noble canes (<i>S. officinarum</i>) are non-flowering in habit. v. The wild genotypes (<i>S. spontaneum</i>) are high fiber, high pipe, poor in yield and sucrose content but normally resistant to red rot disease. Most of them	A)	<i>S. officinarum</i>	: 968		a) Imported	: 352		b) Local Collection	: 158		c) Institute bred	: 458	B)	<i>S. spontaneum</i>	: 36
A)	<i>S. officinarum</i>	: 968														
	a) Imported	: 352														
	b) Local Collection	: 158														
	c) Institute bred	: 458														
B)	<i>S. spontaneum</i>	: 36														

Discipline	Technology generated
	are flowering in habit, profuse tillering and pithy in nature.
b. Plant Breeding	Objective(s): The overall objectives of the division was to develop high yield, high sugar non-lodging, self-detrashing improved varieties with desirable maturity behaviour for sugar production; resistant to major diseases and insect pests; tolerant to agro-climatic stresses (Water-logging, flood, drought, salinity, low temperature etc.); improved varieties for <i>gur</i> production and suitable for chewing purpose. So far, breeding division of BSRI has developed and released 40 high yielding, high sugar varieties, these are being cultivated in 99% of sugarcane areas of mills zone and almost 57% area of non-mill zone. The major varieties are: Isd 2/54I; Isd 16; LJC; Isd 18; Isd 19; Isd 20; Isd 21; Isd 22; Isd 25; Isd 28; Isd 29; Isd 30; Isd 31; Isd 32; Isd 33; Isd 34; Isd 35; Isd 36; Isd 37; Isd 38; Isd 39 and Isd 40 out of which: - Red rot disease tolerant varieties are Isd 30, Isd 36, Isd 37, Isd 38, Isd 39 & Isd 40; - Smut disease tolerant varieties are. Isd 16, Isd 26, Isd 32, Isd 38, Isd 39 & Isd 40; - Water logged and flood stress tolerant varieties are Isd 20, Isd 25, Isd 32, Isd 34, Isd 39 & Isd 40; - Drought stress tolerant varieties are Isd 20, Isd 33, Isd 34, Isd 38, Isd 39 & Isd 40; - Salinity stress tolerant varieties viz. Isd 28, Isd 39 & Isd 40 have been developed; - Varieties suitable for <i>gur</i> production: Isd 16; Isd 26; Isd 30; Isd 35; Isd 36; Isd 37; Isd 38; Isd 39 and Isd 40; - Varieties suitable for chewing and juice production: Isd 24 and Amrita.
c. Biotechnology	Objectives: To develop <i>in-vitro</i> regeneration protocol for plantlets, protocol for molecular characterization of sugarcane varieties and germplasm, transformation protocol using agrobacterium mediated technique to develop transgenic plant tolerant to major abiotic and biotic constraints. The following protocols are developed so far: - Developed protocol of callus culture for sugarcane. - Developed Micro propagation techniques for sugarcane.

Discipline	Technology generated
	iii. developed protocol using leaf segments as explants for rapid multiplication of sugarcane varieties. iv. Development of mushroom production technology using Sugarcane bagasse.
d. Crop and Soil mana-gement	Objectives: To develop management packages for sugarcane production to increase cane and sugar yield by sustaining soil productivity, maximize crop production per unit area and time through intercropping, soil improvement through sugarcane based cropping systems, manage abiotic stresses etc. Achievements: i. Developed profitable sugarcane based cropping system.; ii. Developed planting times and techniques for sugarcane production packages; iii. Developed spaced transplanting (STP) system with different planting materials and optimum spacing for higher plant population resulting higher cane yield; iv. Developed packages of sequential intercropping in single and paired row systems to maximize total crop production per unit area and time. v. Developed ratoon management package; vi. Fertilizer recommendation for sugarcane under different Agro-ecological zones of Bangladesh and Nitrogen fertilization in sugarcane for <i>gur</i> production vii. Fertilizer recommendation for sugarcane production at char land. Integrated application of organic and inorganic fertilizers for multi-ratooning (one plant and three ratoon crops) of sugarcane; viii. Use of dolochun a dolomitic lime $[CaMg(CO_3)_2]$ for sustainable sugarcane production in acidic soils. Use of boron fertilizer for successful sugarcane production in sandy acidic soil; ix. Green manure as second intercrop with sugarcane for sustaining yield and soil health.
e. Pest mana-gement (Diseases & insects)	Objectives: Help develop resistant varieties of sugarcane by screening germplasm, advanced lines, breeding materials against major diseases like red rot (<i>Colletotrichum falcatum</i>), Wilt (<i>Fusarium moniliforme</i>), smut (<i>Ustilago scitaminea</i>) and pests like Early Shoot Borer (ESB), shoot borer (SB), root stock borer (RSB) etc. Study biology of pathogen and insects. Recommend different control measures following IDM and IPM.

Discipline	Technology generated
	Achievements: - Development of red rot disease resistant varieties through screening; - Control of seed borne diseases such as white leaf, smut, leaf scald and red rot by treating seeds at 54°C temperature under 95% humidity; - Control of parasitic weed, Striga, by applying 395kg urea and 247 kg MP/ha in furrow in three installments and applying urea solution (1: 20 ratio) on striga weeds; - Control of pineapple disease by dipping setts in (0.1%) solution of Bavistin 50WP, Knowin 50WP, Genuine 50WP, Evazim 50WP etc. for 30 minutes. Control of ratoon stunting disease by treating setts in hot water (50°C for 3 hours); - Control of pineapple disease by bio-technological means i.e. by dipping sugarcane setts in the spore solution of <i>Trichoderma harzianum</i> for 30 minutes and by spraying spores of this fungus on the setts in the furrows; - Developed cultural control of sugarcane insect pests - Mechanical and chemical control of major insect pests of sugarcane borers; - Biological control of sugarcane stem borer with <i>Trichogramma chilonis</i> Ishii & Pyrillae leaf hopper with egg parasitoids, <i>Tetrastichus pyrillae</i> and ecto-parasite, <i>Epiricania melanoleuca</i>.
f. Physiology	Objectives: Help develop resistant varieties of sugarcane by screening germplasm, advanced lines, breeding materials against abiotic stresses like drought, water-logging, flood and salinity. Achievements: - Screened out sugarcane varieties for drought, water-logging and flood prone areas (listed under breeding) - Development of sugarcane varieties for salinity prone areas (Listed under breeding) - Management of drought, flood and water-logging stress-affected sugarcane.
g. Gur production	Objectives: Help develop sugarcane varieties suitable for gur making, develop commercial good quality gur production and preservation techniques. Achievements: Screened out sugarcane varieties suitable for gur (listed under breeding) and production, packaging

Discipline	Technology generated
	techniques suitable for <i>Gur</i> ii. developed commercial <i>gur</i> preservation technique in cold storage : iii. Recommended vegetative clarificants for <i>gur</i> preparation iv. Developed technique of granule and its preservation v. Developed power crusher for maximum juice extraction from sugarcane for <i>gur</i> making.
h. Agricultural Implements	Objectives: To develop agricultural implements and water management practices for higher sugarcane yield and intercrops production. Achievements: i. Developed BSRI pedal pump, BSRI power weeder, BSRI Power Tiller Mounted Trencher, BSRI paired row trencher, BSRI budchip cutter machine, BSRI mini hot water treatment plant. ii. Irrigation Scheduling, 2-3 irrigation can increase yield of sugarcane by 30%.
i. Agricultural Economics	i. In mill zone area 35.45 percent of the sugarcane farmers use recommended doses of fertilizers (NPK.) and 65.55% do not. Highest sugarcane yield 67.93 t/ha as well as return Tk. 37,270.00/ha obtained by the farmer who used the recommended doses of fertilizer. On the other hand, the farmers who did not use the recommended doses of fertilizer obtained on an average yield 41.33 t/ha and return Tk. 15,332.00/ha. ii. During the cropping season 2005-06 the average yield of sugarcane without and under subsidy program was 47.92 t/ha and 70.17 t/ha respectively. Due to subsidy programme additional yield of sugarcane increased by 22.25 t/ha which resulted in return of Tk. 24,830.00/ha. iii. Price change of sugarcane and sugar is lower than other agricultural crops. Among the agricultural crops price change from 1990-91 to 2006-07 of sugarcane, paddy, lentil and wheat were 40.41, 71.11, 86.25 and 97.80 percent respectively. On the other hand price change of sugar, rice, edible oil and beef were 35.48, 71.21, 41.74 and 206.12 percent respectively. iv. Effective support price of sugarcane for the crushing year was estimated Tk. 1876 per tonne and for sugar Tk. 70000 per tonne. v. Growth rates of sugarcane area, production, growers'

Discipline	Technology generated
	cane supply to the mill, sugar production, recovery and sugarcane price were 1.3, 3.1, 2.9, 3.0, 0.00 and 5.6 percent respectively
	vi. On an average the palmyra palm farmers of South-western part of Bangladesh got 34.39 kg <i>gur</i> , 180.23 kg juice, 150 no. of green fruits and 40 no. of ripen fruits in a season per tree. By selling them the farmers got net return of Tk. 780.70, Tk. 350.00, Tk. 300.00 and Tk. 120.00 respectively from a tree in a season.
	vii. The investment return of sugarcane variety /technology of Isd 2/54, Isd-16, LJC, use of Curbofuran, applied fertilizers as recommended doses and intercropping cultivation was 26%, 28%, 23%, 44%, 40% and 28% respectively.

Demand and Supply

According to FAO recommendation 13 kg sugar is required per capita for human dietary and as such present requirement of sugar for 145.91 million people in Bangladesh is about 1.89 million tonnes. Considering the amount of taking 13 kg sugar per person per year, annual requirement of sugar will be 2.06 million tonnes by 2015 (projected population 158.96 million); 2.21 million tons by 2020 (projected population 170.32 million) and 2.53 million tons by 2030 (projected population 195.53 million). The domestic production of sugar and *gur* for the projected population will need to be 0.54, 0.60 and 0.74 million tons in 2015, 2020 and 2030 respectively against the present production of 0.4 million tons of sugar and *gur*.

If we analyze the present demand and supply of sugar + *gur* and projected demand and supply of the same as presented in Table 7, we see that at present the demand is 1.89 million t against which we produce only 0.40 million t (21.29%). But if we see the supply from 1990-2000, it is 37.66% which come down to 27.44 during the next 10 years (2001-2009) as shown in the Table 5. On the other hand import of sugar tremendously increased from 138 thousand tons in 1990-91 to 1300 thousand tons in 2008-09 to meet the gap between demand and supply (Table 6). But still there was 272.8 thousand tons of shortage.

Table 6. Demand, supply and gap analysis of sugar and gur in Bangladesh

Crush ing Season	Popula tion (million)	Demand of sugar & gur ('000 t) (per capita 13 kg)	Sugar produc tion (‘000 t)	Sugar import (‘000 t)	Gur Pdn (‘000 t)	Supply of sugar & gur (‘000 t)	Shortage (‘000 t)
1990-91	109.60	1425.00	246.00	138.00	432.00	816.00	609.00
1991-92	111.40	1448.00	195.00	5.00	482.00	628.00	820.00
1992-93	113.20	1472.00	187.00	64.00	415.00	666.00	806.00
1993-94	117.70	1530.00	221.00	86.00	334.00	641.00	889.00
1994-95	119.90	1559.00	270.00	156.00	285.00	711.00	848.00
1995-96	122.10	1587.00	184.00	28.00	371.00	583.00	1004.00
1996-97	124.38	1617.00	135.00	207.00	463.00	805.00	812.00
1997-98	126.71	1647.00	166.00	160.00	415.00	741.00	906.00
1998-99	129.08	1678.00	153.00	191.00	359.00	703.00	975.00
1999-00	131.49	1709.00	123.00	115.00	427.00	665.00	1044.00
2000-01	132.00	1716.00	98.00	328.00	436.00	862.00	854.00
2001-02	133.00	1729.00	205.00	210.00	306.00	721.00	1008.00
2002-03	134.00	1742.00	177.00	600.00	322.00	1099.00	643.00
2003-04	135.20	1757.60	119.00	440.00	371.00	930.00	827.60
2004-05	137.00	1781.00	107.00	687.00	462.00	1256.00	525.00
2005-06	138.80	1804.40	133.00	625.00	333.00	1091.00	713.40
2006-07	140.60	1827.80	162.00	594.00	310.00	1066.00	761.80
2007-08	143.91	1870.83	164.00	1200.00	299.00	1499.00	371.83
2008-09	145.91	1896.83	80.00	1300.00	324.00	1624.00	272.83

Source: BSS, BSFIC, DAE.

Now if we consider the area of sugarcane of last 10 years it stands around 0.16 million ha. On this basis if we assume that the area will decrease to 0.14 million ha in 2015, 0.135 in 2020 and 0.13 million ha in 2030 then we have to increase the yield to 45 t/ha with sugar recovery of 8.5%, 50 t/ha with recovery of 9% and 60 t/ha with recovery of 9.5% respectively to maintain our supply of 26%, 27% and 29% in these years. For these we will need to develop appropriate technologies to enhance cane production as well as improve sugar recovery process (starting from extraction and modernization of sugar mills).

Table 7. Production target in 2015, 2020, 2030

Particulars	Present status	Projected Increase		
		2015	2020	2030
Population (million)	145.91	156.79	170.90	195.53
Sugar /gur required (million mt)	1.89	2.06	2.21	2.53
Sugar /gur production (million mt)	0.40	0.54	0.60	0.74
Sugarcane production (million mt)	6.3*	63	6.75	7.8
Sugarcane area (million ha)	0.16*	0.14	0.135	0.13
Cane Yield (t/ha)	40.00*	45.00	50.00	60.00
Average recovery (sugar + gur)	7.8	8.5%	9.0%	9.5%

* Average of last 10 years

4.1.4 Research Priorities

4.1.4.1. Research Agenda/Thematic Area: Genetic resources

Problem/ Constraints	Research Title/ Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Medium	Long
Genetic resources	• Latest foreign germplasm to be collected	100	50	1	Continue	Continue	Continue
	• Development of parent materials from own source (genetic enhancement)	100	80	1	Continue	Continue	Continue
	• Characterization of collected germplasm	100	75	1	Continue	Continue	Continue
	• Evaluation against different stress to identify resistant genes	100	65	1	Continue	Continue	Continue
	• Photoperiodic regulation of flowering	100	50	1	Continue	Continue	Continue

4.1.4.2. Research Agenda/Thematic Area: Plant Breeding

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Medium	Long
Crop Improvement	• Development of Red rot resistant varieties with high yield and high sugar potential	70	40	1	Continue	Continue	Continue
	• Development of smut resistant varieties with high yield and high sugar potential	40	35	2	Continue	Continue	Continue
	• Development of stress (drought, water logged, flood and salinity) tolerant varieties with high yield and high sugar potential	40	50	1	Continue	Continue	Continue
	• Varieties for <i>gur</i> making	45	50	2	Continue	Continue	Continue
	• Varieties for chewing and juice	30	75	3	Continue	Continue	Continue
	• High ratoon potential	100	50	1	Continue	Continue	Continue
	• HYV responsive to less inputs	50	40	3	Continue	Continue	Continue

4.1.4.3. Research Agenda/Thematic Area: Biotechnology

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Crop Improvement	• Molecular characterization (finger printing) of varieties	50	100	1	Initiate	Continue	Continue
	• Identification and sequencing of red rot resistant gene (RR)	100	60	1	*	Initiate	Continue
	• Make construct of RR genes and develop transformation protocol	100	55	1	*	Initiate	Continue
	• MAS for red rot resistant genotypes	100	60	1	*	Initiate	Continue
	• Inter specific hybridization following embryo rescue	50	50	2	*	Initiate	Continue
	• Marker assisted selection (MAS) for development of high yielding, high sugar, diseases and pest resistant varieties with tolerance to water-logging, drought and salinity stresses.	100	20	1	Initiate	Continue	Continue
	• Genome sequencing to know the functions, positions and nature of genome segments against desired traits	50	50	2	*	Continue	Continue
	• Gene isolation, construction and transformation.	100	50	1	*	Continue	Continue

Note: * Lab facilities and human resources need to be developed

4.1.4.4. Research Agenda/Thematic Area: Plant Pathology

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Crop Protection	• Searching for resistant source against red rot	100	60	1	Continue	Continue	Continue
	• Identification of new race/ biotypes of red rot pathogen through biotechnology	100	50	2	*	Initiate	Continue
	• Searching for resistant variety against smut disease with higher yield	100	100	1	Initiate	Continue	Continue
	• Identification of new race/ biotypes of smut pathogen through biotechnology	50	50	2	*	Initiate	Continue
	• Searching for resistant variety against wilt disease with higher yield	100	100	2	*	-	Initiate
	• Searching for resistant variety against white leaf disease with high yield potential	30	50	3	*	-	Initiate
	• Searching for resistant variety against pineapple disease with high yield potential	30	100	2	*	-	Initiate
	• Continuous monitoring of new disease and pathotypes	100	50	1	Continue	Continue	Continue

Note: * Lab facilities and Human Resources need to be developed

4.1.4.5. Research Agenda/Thematic Area: Entomology

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Crop Protection	Top shoot borer:						
	• Searching tolerant variety with higher yield and sugar potential	100	40	3	Initiate	Continue	Continue
	• Manipulation of resistance through biotechnology	100	20	3	*	Initiate	Continue
	• Develop new management practices	100	80	1	Continue	Continue	Continue
	• IPM (use of sex pheromone and bio-agent)	100	85	1	Initiate	Continue	Continue
	Stem borer:						
	• Search tolerant variety with higher yield and sugar potential	100	40	3	Initiate	Continue	Continue
	• Manipulation of resistance through biotechnology.	100	20	3	*	Continue	Continue
	• Develop new management practices.	100	80	1	Initiate	Continue	Continue
	• IPM (use of sex pheromone and bio-agent)	100	85	1	Initiate	Continue	Continue
	• Use of silicon to control stem borer	100	50	3	*	Initiate	Continue

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
	Rootstock borer:						
	• Search tolerant variety with higher yield and sugar potential	100	40	3	Initiate	Continue	Continue
	• Manipulation of resistance through biotechnology	100	10	3	*	Initiate	Continue
	• Develop new management practices	100	75	1	Initiate	Continue	Continue
	White grubs:						
	• Search tolerant variety with higher yield and sugar potential	100	40	3	Initiate	Continue	Continue
	• Develop eco-friendly control method	100	80	2	Initiate	Continue	Continue
	• Use of entomophilic nematode	50	50	3	Initiate	Continue	Continue
	Termites:						
	• Search tolerant variety development	100	10	3	Initiate	Continue	Continue
	• IPM (use of different bio-agent)	100	50	3	Initiate	Continue	Continue

Note: * Lab facilities and human resources need to be developed

4.1.4.6. Research Agenda/Thematic Area: Agronomy

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Crop Production	Reduce yield gap with farmers participatory adaptive research on :						
	Optimum crop management for maximizing yield	100	80	1	Initiate	Continue	Continue
	Multiple cropping	40	100	1	Initiate	Continue	Continue
	Spaced transplanting (STP)	40	100	1	Initiate	Continue	Continue
	New cropping pattern (crop sequence) e.g. jute/short duration Aman rice followed by STP cane	40	60	2	Initiate	Continue	Continue
	Mechanization of sugarcane production	50	40	3	-	Initiate	Continue
	Screen out potential & economic intercrops with farmers participation	40	100	1	Initiate	Continue	Continue
	Crop diversity:						
	Intercropping with short duration high value winter crops	40	75	1	Initiate	Continue	Continue
	Early plantation:						
	Jute-Sugarcane/Early T. Aman-Sugarcane cropping	40	40	3	Initiate	Continue	Continue

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
	system						
	Increasing yield under late plantation specially using non-flowering varieties and STP method	40	50	2	Initiate	Continue	Continue
	Ratoon Management:						
	Maximize ratoon yield through ratoon potential varieties and management practices	50	100	1	Initiate	Continue	Continue
	Weed management:						
	Mechanized weeding	75	60	2	Initiate	Continue	Continue
	Use of selective herbicides	50	50	3	Initiate	Continue	Continue
	Water management:						
	Develop irrigation and drainage system to maximize sugarcane and intercrops yield	40	60	1	Initiate	Continue	Continue

4.1.4.7. Research Agenda/Thematic Area: Crop Physiology & Sugar Chemistry

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Crop and <i>Gur</i> Production	Searching for flood, waterlog and drought tolerant varieties with higher yield potential using appropriate methods.	40	60	1	Initiate	Continue	Continue
	Synchronization of flowering of <i>S. officinarum</i> and <i>S. spontaneum</i> for crossing	100	40	1	Initiate	Continue	Continue
	Develop new management practices for sugarcane cultivation in saline area	15	70	2	Initiate	Continue	Continue
	Searching new technologies for stress management (flood, drought, water logg etc.)	40	65	2	Initiate	Continue	Continue
	Searching early maturing varieties with high yield and sugar potential	80	70	1	Initiate	Continue	Continue
	Low cost preservation and drying systems for <i>gur</i>.	40	50	2	Initiate	Continue	Continue
	Searching of more effective new plant clarifiers for <i>gur</i>.	70	40	2	Initiate	Continue	Continue

4.1.4.8. Research Agenda/Thematic Area: Soils & Nutrition

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Crop Production	Biological Nitrogen Fixation (BNF) in sugarcane:	100	80	1	Initiate	Continue	Continue
	Maintenance of soil fertility and soil health:						
	• Refining the recommended fertilizer dose for different zones.	100	100	1	Initiate	Continue	Continue
	• Soil improvement through incorporation of green manure crops.	50	60	2	Initiate	Continue	Continue
	Recycling of farm and factory wastes in crop production and soil health:	30	100	2	Initiate	Continue	Continue
	• Studies with rapid degradation of long chain carbonaceous materials and their uses in crop production and soil health	50	50	2	Initiate	Continue	Continue
	Mitigation of soil salinity developed in coastal area:				Initiate	Continue	Continue
	• Amendment with divalent cautions and other appropriate nutrient to mitigate salinity problems in crop production	15	50	2	Initiate	Continue	Continue
	• Study on salt balance and the natural factors affecting the salt regime to understand the process of salinization for developing preventive/ declamation measure	15	50	2	Initiate	Continue	Continue
	Mitigation of soil Acidity :						
	• Research will be continued with new crops as intercropping in acidic soils	15	50	3	Initiate	Continue	Continue

4.1.4.9. Research Agenda/Thematic Area- 1: Agricultural Engineering

Problem/ Constraints	Research Title/Key Words	% of beneficiary	Probability of success in %	Priority Ranking	Research Tenure		
					Short	Med	Long
Agricultural Implements	Land preparation:						
	• Improvement of plough, furrow and trencher	60	85	1	*	Initiate	Continue
	Fertilizer application:						
	• Development of power operated fertilizer applicator for sugarcane	50	50	2	*	Initiate	Continue
	Pesticide application:						
	• Development of power operated pesticide applicator for sugarcane	30	50	2	*	Initiate	Continue
	• Development of power operated harvester for sugarcane	25	20	3	*	Initiate	Continue
	• Develop low cost crusher & improved pan & <i>chula</i> for economic <i>gur</i> production	100	75	1	Initiate	Continue	Continue

Note: * Lab facilities and Human Resources need to be developed

4.1.5 Opportunities

To narrow down the deficit of 1.1 million tonnes of sugar and *gur*, both vertical and horizontal expansions of sugarcane production are necessary. At present horizontal expansion of sugarcane cultivation is very difficult competing with other short duration high value crops. But still some new area can be brought under sugarcane in southern Bangladesh and hilly areas. However there is a great scope for vertical expansion through increasing yield of sugarcane and some other suitable short duration multiple intercrops with modern varieties and cultivation technologies. The average yield of more than 65 t/ha was obtained from BSRI varieties with optimum management packages, STPs etc. in the farmers' field demonstration plots. Again sugarcane is commonly kept as ratoon crops that gives poor yield but contains high sucrose. Thus, through cultivation of methodical multi ratooning of sugarcane with intercrops, high yield of sugarcane and other companion crops can be achieved from the same land. Sugarcane is comparatively drought tolerant crop that can withstand considerable flooding and can be grown in low fertile and saline soils. Due to climate change our rainfall pattern and temperature sequence is going to be changed, that can be faced by ensuring sugarcane cultivation, which has the in born quality to survive and face that abnormal situation to some extent. Furthermore, sugarcane physiologically belongs to C-4 crops; it has higher potentiality to utilize atmospheric carbon giving higher biomass yield and mitigating higher carbon concentration present in nature due to green house effect and climate change.

4.1.6 Conclusion

Now a target oriented research like development of high yield, high sugar variety utilizing *S. spontaneum* using biotechnological tools should be given top priority. For this lab facilities and human resource development are prerequisite. Now-a-days sugar surplus countries are switching towards bio fuel production (ethanol), thus it would be difficult to buy sugar from outside due to short fall in international market. Thus, our government should strongly patronize sugarcane crop production with a long term vision and mission to fulfill our own consumption of sugar and *gur*. Large scale subsidy to sugarcane farmers for encouraging cane cultivation, high and reasonable price for the crop, subsidies to sugar mills should also be given. Crushing capacity of sugar mills must be enhanced

through BMRE and modernization to achieving high recovery. In the long term vision 2030 we do not have any option to avoid sugarcane cultivation and sugar production in the country, but to invest our proper resources and all out efforts for sustaining sugarcane and sugar production by our own. Simultaneously modern varieties for *gur* production along with modern cultivation practices and intercrops should be introduced in the *gur* zones. *Gur* production with high capacity crusher should be developed to meet our national demand.

4.2 Jute

4.2.1 Introduction

Jute is an industrial cash crop grown in Bangladesh. It is also grown in India, Nepal, Thailand, Myanmar, and China but the best quality jute is produced in Bangladesh. It is used to make gunny bags, ropes, carpet, geo-textiles, twin, fine yarns, cloths mixed with cotton etc. Jute and jute products are the major agricultural export items of Bangladesh. Therefore, it is called the golden fibre of Bangladesh. In 2007-08, Bangladesh earned Tk. 36300 million by exporting 5410.55 thousand bales of jute (Economic Trends, January 2009, Bangladesh Bank). On an average it contributes about 4.21% of country's total export earnings (Economic Trends, January 2009, Bangladesh Bank).

In Bangladesh two species of jute are cultivated in two ecosystems- *Corchorus capsularis* in low land and it can withstand water logged condition and *Corchorus olitorius* under upland condition. Presently jute is grown on about 0.50 million ha which is 2.6% of the total net cropped area. Out of this *C. capsularis* occupies 20% and *C. olitorius* occupies 80% area and their productions are 0.96 million bales and 4.37 million bales respectively (Jute, Kenaf, Sisal, Abaca, Coir and Allied Fibres Statistics, FAO June 2008).

C. capsularis and *C. olitorius* are grown in the following cropping patterns

- (i) Jute - T. Aman rice - Wheat (AEZ no. 2, 3, 9, 11, 12 and 19)
- (ii) Jute - Green gram - Lentil + Mustard (AEZ no. 11 and 12)
- (iii) Jute - Radish - Potato + Amaranthus + Sweet gourd (AEZ no. 3, 8, 12 and 16)
- (iv) Jute - Black gram - Wheat (AEZ no. 3, 8 and 12)
- (v) Jute - T. Aman rice - Potato (AEZ no. 2, 3, 8 and 12)

- (vi) Jute - T. Aman rice - Maize (AEZ no. 7 and 8)
- (vii) Jute - Radish - Potato (AEZ no. 8)
- (viii) Jute - T. Aman rice - Potato + Data (AEZ no. 3, 7, 8 and 12)
- (ix) Jute - T. Aman rice - Chilli + Tomato + Coriander (AEZ no. 3, 7, 8 and 12)
- (x) Jute - T. Aman rice - Onion/Garlic (AEZ no. 2, 3, 9, 11, 12 and 19) etc.

Apart from jute there are two other minor fibre crops such as kenaf (*Hibiscus cannabinus* L.) and mesta (*Hibiscus sabdariffa* L.) which are sporadically cultivated in some pockets of the country. The area of kenaf and mesta cultivation of the country is about 0.15 lakh hectare and primarily used as like as jute fibre.

The recent acreage and production of these fibre crops are shown below

Crops	Year	Area (000 ha)	Production (000 bales)	Yield (bales/ha)
Jute	2003-04	499.80	5350.00	10.70
	2004-05	450.00	4500.00	10.00
	2005-06	500.00	5500.00	11.00
	2006-07	500.00	5500.00	11.00
	2007-08	500.00	5500.00	11.00

Trend of area and production:

The area, production and yield of jute for the last 37 years (1972-2006) are shown in Figure 2. It appears from the graph that the average area of jute during 1972-1985 was 690 thousand ha and production 5106 thousand bales; from 1987-1998 these were 552 thousand ha and 5003 thousand bales and those of 1999-2006 were 463.50 thousand ha and 4943 thousand bales respectively. The average yields of these three periods were 8.19 bales, 9.08 bales and 10.64 bales/ha respectively. The exception year was 1986. In this year highest jute area recorded was 1.06 million ha and production was 8.7 million bales. Hence this year was excluded from calculation.

Yield gap analysis:

From the statistics it is quite clear that the area has continuously declined from 690 thousand ha to 463.50 thousand ha during these decades. Production has also declined from 5106 thousand bales to

4943 thousand bales and jute is being pushed to the marginal land due to expansion of food crop cultivation. However yield per unit area (ha) has increased from 8.19 bales to 10.64 bales over the period from 1972 to 2008. This is due to dissemination of modern technologies including high yielding varieties of jute at farmers' level. But the average yield obtained from varietal demonstration during the last few years at farmers' field is 16.50 bales. Mean yield per ha of the modern varieties of jute at research station with optimum management is 22.20 bales which is almost double of the national average. The low yield at farmers' field and shrinking of the area and production of jute is due to various biotic, abiotic and social constraints, which are discussed below:

4.2.2 Constraints

A. Biotic constraints:

So far 40 varieties have been released but none is resistant to major diseases and insects.

Diseases:

a) Stem rot:

It is one of the major diseases of jute, kenaf and mesta. This disease is caused by *Macrophomina phaseolina* and causes moderate to severe yield loss (17% to 20%) depending on its incidence. Environmental factors mainly high temperature, high humidity (moist weather), excessive nitrogen, and low potash content influence to occur this disease.

b) Anthracnose:

This disease is caused by *Colletotrichum corchori* and confined only to *Corchorus capsularis* varieties. This disease is seed, soil and air borne. The etiology of the disease shows that it can spread very fast under high temperature and humidity. It causes enormous loss to jute production up to 60% at epidemic condition.

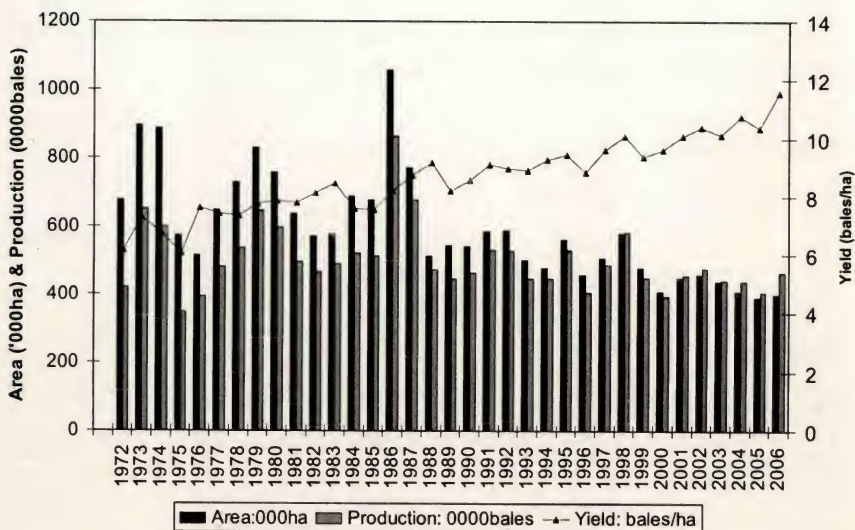
c) Die back:

Glomeralla cingulata is the causal organism of the disease. It causes 30% yield loss when it appears at epidemic form. The disease can become very serious if the standing plants

get somehow bruised either by the lashing of stormy weather.

d) Leaf Mosaic:

Its causal organism is unidentified yet. It is assumed that the causal organism may be virus or mycoplasma. Infected plants at primary stage show stunted growth affecting fibre yield up to 70%. Olitorius varieties are immune to this disease. At drought condition it spreads very fast.



Source: BBS

Figure 2 Area, production and yield of jute

Insects:

a) Yellow mite:

The jute yellow mite *Polyphagotarsonum latus* is a major pest of jute. It causes damage to both fibre and seed crops. It attacks the apical leaves and causes damage by sucking the plants sap. It spreads in drought condition. The loss in fibre yield is about 18.9 % in severe infestation.

b) Apion:

Jute stem weevil *Apion corchori* is another major pest of jute. The female weevil bores a hole on the stem and

deposit egg singly. It attacks from seedling stage to harvest time and it also attacks pods of cultivated species. Its population reaches maximum at the end of July.

c) Mealybug:

Next to jute mealy bug is a major pest of mesta. Both nymphs and adult feeds on plant sap causes swelling of terminal shoot. It also attacks jute in the late season. The infestation appears in mesta fields in July to late August. The loss of fibre varies from 4-6 maunds per acre (0.1-0.6 t/ha) in case of serious infestation.

4.2.3 Research Progress

Keeping all the factors in view the BJRI has been trying to develop suitable technologies to tackle these challenges not only to sustain jute acreage but to produce more fibre from the same land and make jute cultivation profitable. Some important achievements of jute research institute are as follows:

Division/ Discipline	Technology Generated										
Genetic Resources and Seed Division	Objectives: 1. Collection, conservation, characterization and documentation of jute, kenaf and mesta germplasm 2. Micropropagation and genetic transformation of jute and allied fibre crops 3. Molecular characterization of jute and allied fibre crops through DNA fingerprinting 4. Production and distribution of breeder seeds of different jute and Kenaf varieties as per national requirement 5. Conduction of research on different aspects of jute and allied fibre crops seed quality. Achievements: 1. A total of 5936 accessions of jute and allied fibre germplasm have been collected and conserved in Gene Bank and gradually characterized and evaluated for different traits. Species wise number of accessions conserved in Gene Bank are as follows: <table data-bbox="338 1428 872 1583"> <tr> <td>White jute (<i>Corchorus capsularis</i>)</td><td>: 2380</td></tr> <tr> <td>Tossa jute (<i>C. olitorius</i>)</td><td>: 1450</td></tr> <tr> <td>Kenaf (<i>Hibiscus cannabinus</i>)</td><td>: 688</td></tr> <tr> <td>Mesta (<i>Hibiscus sabdariffa</i>)</td><td>: 426</td></tr> <tr> <td>Allied spp. germplasm</td><td>: 992</td></tr> </table> So far, half of the above accessions have been characterized and	White jute (<i>Corchorus capsularis</i>)	: 2380	Tossa jute (<i>C. olitorius</i>)	: 1450	Kenaf (<i>Hibiscus cannabinus</i>)	: 688	Mesta (<i>Hibiscus sabdariffa</i>)	: 426	Allied spp. germplasm	: 992
White jute (<i>Corchorus capsularis</i>)	: 2380										
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Mesta (<i>Hibiscus sabdariffa</i>)	: 426										
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Division/ Discipline	Technology Generated			
	evaluated, produced a number of promising accessions of different traits. By utilizing those promising accessions BJRI has been developing varieties of good quality and high yield. 2. Development of plant regeneration protocol from the explants of jute, kenaf and mesta. 3. Development of genetic transformation protocol for transferring salt tolerant genes in jute, kenaf and mesta. Breeder seed production and supply to BADC and other organization every year as per their demand as well as conduction of experiments on seed quality parameters.			
Breeding Division	Objectives : The overall objective of breeding division was to develop high yielding with good quality fibre and disease and abiotic stress tolerant varieties of jute and allied fibre for cultivation in the traditional and non-traditional areas of Bangladesh. Achievements : Against this objective BJRI has developed a total of 40 varieties so far and out those, 14 varieties are now widely cultivated in the farmers' field.			
	Variety	Year of release	Fibre yield (in farmers condition) (t/ha)	Special feature
DESHI PAT				
	BJRI Deshi Pat-1 (D-154)	1961	2.00-2.30	Wider adaptability, variation in fruit colour, suitable for medium low land of late sowing. After harvest late Aman can be transplanted.
	BJRI Deshi Pat-2 (CVL-1) Sabuj Pat	1977	2.00-2.46	Most tolerant to mosaic virus. Fine and strong fibre, less cuttings, suitable for late sown areas. After harvest late T. Aman can be transplanted.
	BJRI Deshi Pat-3 (CVE-3) Ashu Pat	1977	1.50-1.97	Suitable for early sown area. Quick growing variety. Early maturing. After harvest early T. Aman

Division/ Discipline	Technology Generated			
				can be transplanted. Fibre fine and lusturous.
	BJRI Deshi Pat-4 (CC-45) Jo-Pat	1979	2.00-2.49	Short day insensitive, no risk of premature flowering, very wider time for sowing, suitable for a 3 crop pattern. So more profitable in early cropping with onion/garlic. Fibre fine and very strong. After early harvest early T. Aman can be transplanted.
	BJRI Deshi Pat-5 (BJC-7370))	1995	2.00-2.45	Short day tolerant, free from early flowering, produce sufficient seed and can be harvested one month earlier than the existing varieties of white jute, thus land becomes free for rabi cropping. This is the only blue seeded capasularis variety.
	BJRI Deshi Pat-6 (BJC-83)	1995	2.00-2.12	The whole plant is green, fast growing and early maturing type and can be harvested about one month earlier than the existing varieties, suitable for 3 crop pattern.
	BJRI Deshi Pat-7 (BJC-2142)	2007	2.50-3.00	Short day and low temperature tolerant, early seeding white jute. Performed better than existing varieties CC-45 and CVE-3 at farm level. Better fibre quality give additional return. Recommended for cultivation in

Division/ Discipline	Technology Generated			
				greater Faridpur.
TOSSA PAT				
	BJRI tossa Pat-1 (O-4)	1967	2.00-2.32	Wider adaptability, suitable for late sown areas, fibre fine and strong with least cutting, after early harvest late T. Aman can be grown.
	BJRI tossa Pat-2 (O-9897)	1987	2.50-2.75	Short day insensitive, free from premature flowering, wide time of sowing, suitable for 3-crop pattern, fibre fine, strong and lower cutting, after early harvest early T. Aman can be transplanted.
	BJRI tossa Pat-3 (OM-1)	1995	2.00-2.49	Less photosensitive, performed better than the existing variety O-9897, suitable for early sowing and for 3-crop pattern, fibre fine strong and lower cutting than the existing. This is the only brown seeded olitorius variety.
	BJRI tossa Pat-4 (O-72)	2002	2.50-2.90	Less photosensitive, performed better than the existing variety O-9897, fibre fine, strong and least cutting than the existing varieties.
	BJRI tossa Pat-5 (O-795) Lal tossa	2008	2.50-3.40	Less photosensitive, i.e. no possibility of early flowering even seeded in the 1 st week of March. Stem reddish, stipule red, fibre bright golden, higher bark thickness and higher stick strength and can yield 10% higher fibre than

Division/ Discipline	Technology Generated			
				the existing variety O-72.
	KENAF			
	HC-2 (Joly Kenaf)	1977	3.50-4.50	Rapid growth, suitable for high, medium, low, less fertile, marginal, <i>char</i> , hilly and flood affected land. Fibre is bright and shiny. Green plants with cordate leaves. Excellent raw materials for paper pulp. Seeds contain about 20% edible oil.
	HC-95 (Kenaf)	1995	4.00-5.00	Suitable for high, medium, low, less fertile, marginal, <i>chars</i> , hilly, <i>haor</i> and flood affected land. Fibre is bright and shiny. Green coppery red pigmented plants with lobed leaf. Excellent raw materials for paper pulp, seeds contain about 20% edible oil. Oil cake can be used as cattle feed.
	MESTA			
	HS-24 (Tani mesta)	1977	3.00-3.50	Suitable for high, less fertile, marginal and drought affected land. After harvest T. Aman can be grown. Resistant to root-knot nematodes, seeds contain about 20% edible oil.
Agronomy Division	Objectives: To develop management packages for jute and allied fibers to maximize yield by sustaining soil productivity, off season seed production technique for jute, soil improvement through jute based cropping patterns, manage abiotic stresses etc.			

Division/ Discipline	Technology Generated
	Achievements: 1. Developed late jute seed production techniques by direct seeding, stem cutting, seedling transplantation. 2. Developed cultural management practices like optimum sowing time, weed control, irrigation scheduling for both olitorius and capsularis jute varieties. 3. Developed fertilizer doses for all the varieties of jute, kenaf and mesta developed so far from BJRI and seed production. 4. Method of fertilizer application (split N etc). 5. Impact of chemical fertilizers on fibre quality, soil borne disease etc. 6. Determined physiological maturity stage of <i>C. olitorius</i> and <i>C. capsularis</i> and seed production efficiency of different varieties round the year. 7. Developed seed storage techniques at farm level.
Pest Management Division (Diseases & insects)	Plant Pathology Department Objectives: Provide assistance to develop disease resistant variety through screening germplasm, assessing incidence of different diseases at different agro ecological zones and to find out their suitable control measures. Achievements: 1. Identified 19 physiological races of <i>Macrophomina phaseolina</i>, 9 of <i>Botryodiplodia theobromae</i>, 6 of <i>Colletotrichum corchori</i> and 4 of <i>Sclerotium rolfsii</i> causing stemrot, black band, anthracnose and soft rot disease of jute. 2. Screened 1450 nos. germplasms against different fungal diseases and found 35 resistant and moderately resistant genotypes against different fungal diseases. 3. Identified 15 nos. of fungicide for controlling different fungal diseases of jute, kenaf and mesta. 4. Identified 7 nos. of seed treating chemicals for controlling different seed borne diseases of jute, kenaf and mesta. 5. Identified Furadan 5G as chemical control agent for controlling root knot nematode. 6. Identified trap crops i.e., kushum phool, marigold, sunhemp and kaon for controlling nematode disease. 7. Rotten poultry litter was identified as soil amendment component for controlling root knot nematode. 8. Developed suitable botanicals (garlic paste @ 12.5% per kg seed) for controlling seed borne pathogens of jute, kenaf and mesta.. 9. Detected transmission mode of leaf curling and leaf yellowing diseases of kenaf. 10. Roughing out of leaf mosaic affected plant at primary stage for controlling mosaic disease of jute.

Division/ Discipline	Technology Generated
	11. Thiovit identified as chemical control agent of powdery mildew of jute. 12. Practices like keeping land fallow and rotational cultivation of mesta to control the nemtic disease of jute recommended. Entomology Department Objectives: Provide assistance to develop insect and mite pest resistant variety of jute, kenaf and mesta through screening germplasm, assessing incidence of different insect and mite pest infestation at different agro-ecological zones and to find out their suitable control measures, disseminate technologies of jute pest control. Achievement: d) More than 24 acaricides and 30 insecticides were tested, standardized and recommended for the growers. e) Rating index (0-5 rating scale) has been developed to measure yellow mite infestation. f) Rating index (0-5scale) has been developed to measure tolerant/ resistant variety against apion infestation. g) Yield losses due to some jute pest have been established which are 18.9% by yellow mite, 13.4% by semilooper, 10.2% by hairy caterpillar, and 12% by insect pest complex. h) Rouging out of top shoot attacked plant by apion for controlling further dissemination of insect. i) Seating arrangement of insectivorous bird for controlling semilooper, indigo caterpillar and cutworm. j) White fly <i>Bemesia tabaci</i> has been identified as the vector of leaf mosaic of jute. k) About 14 predators and parasitoids of jute pest have been identified. l) Technology "Management of jute hairy caterpillar by hand picking" has been developed. m) Use of green neem leaf extract, dry neem leaf extract, turmeric powder and garlic extract for the control of jute yellow mite.
Fibre Quality Improvement Division	Objectives: To develop techniques for accelerating jute retting and improve quality, especially, colour of jute fibres using microbes and plant materials. Achievements: 1. The highest microbial population in the upper layers of water helps better retting. Other factor such as age of plant,

Division/ Discipline	Technology Generated
	temperature and pH of retting water etc. influence retting and quality of jute fibre. 2. Besides improvement of traditional retting, BJRI developed ribbon retting and low cost retting for water scarce areas. 3. Blue green algae, leguminous plants like dhaincha, sunhemp accelerate retting process. 4. Up grading of baky jute by growing fungus on this. The dark grey colour of jute can be improved by application of tamarind solution. 5. Biogas containing 64% methane can be produced from starting to end of retting.
Jute Farming Systems Division	Objectives: To develop sustainable jute based cropping patterns, validification of developed technologies of BJRI and dissemination of technologies to farmer in small scale. Achievements: 1. Development of 14 (Fourteen) jute based cropping patterns. 2. Transfer and disseminate the technologies on improved jute production and jute-based cropping patterns to jute farmers and trained DAE personnel etc. 3. Organized hand-on training programs for farmers and DAE personels through field days and demonstrations in different locations of jute growing areas of Bangladesh.
Mechanical Processing Division	Objectives: 1. Improvement and cost reduction of traditional jute products. 2. Studies for production of fine jute yarns (low count <5 lb/spy) from jute/blended in various processing systems. 3. Blending/Union of jute with natural and synthetic fibres/yarns. 4. Development and modifications of machinery and equipment for jute and jute products. 5. Technical services/assurances to different organizations. Achievements: 1. Modification of existing apron draft spinning machine for production of fine yarn. 2. Production of blended jute yarn with different fibres. 3. Production of union fabrics of different designs using blended yarns of jute as weft and cotton yarn as warp. 4. Production of blankets using blended yarns of jute. 5. Production of bio-degradable and environmental friendly light weight shopping bag of jute.

Division/ Discipline	Technology Generated
Textile Physics Division	Objectives: 1. Improvement and cost reduction of traditional jute products. 2. Studies on intrinsic and extrinsic properties, micro and macro properties of jute and jute products and their modification with physical, chemical and other possible means. 3. Studies for production of fine jute yarns, all jute blended in various processing systems. 4. Studies for blending/union of jute with natural and synthetic fibres/yarns. 5. Studies for the development of physico-mechanical properties of jute and jute-allied fibres, yarns and fabrics to diversify uses of jute and its products. 6. To modify/develop the existing electronic and electrical equipments and machinery. Achievements: 1. A process has been developed for the production of jute-cotton blended yarn using short staple spinning technology. 2. A quick method has been developed to determine the fineness of jute fibre using sonic fineness tester used for measuring fineness of wool. 3. Thermal conductivity measuring equipment has been modified using a variable transformer and an enclosure has been attached for avoiding heat loss.
Chemistry Division	Objectives: 1. Elucidation of chemical composition including chemical structure of jute fibre and mode of association of the individual constituents of the fibre. 2. Finding out newer uses of jute by special chemical treatment, which would impart/improve new properties of jute and jute products. 3. Process development for bleaching, dyeing, printing and finishing of jute and jute products by chemical means.
	Achievements: 1. Development of improved dyeing and printing techniques for jute materials. 2. Development of softening of jute cuttings. 3. Development of chemical procedure for jute fibre modification. 4. Production of microcrystalline cellulose and carboxymethyl cellulose from jute. 5. Development of process for fire retardant jute fibre/fabrics. 6. Extraction of vegetable dye from <i>Bixa orellana</i>.
Microbio- logy & Bio- chemistry	Objectives: 1. Collection and preservation of new sources of microorganisms for obtaining lignocellulolytic enzymes

Division/ Discipline	Technology Generated
department	(viz. cellulase, xylanase, pectinase etc.) - Improvement of jute and allied fibre through microbial and biochemical means. - Biochemical modification of jute and allied fibre to be used in various purposes. - Biotechnological utilization of leaves, seeds and other parts of jute plant as vegetables, medicine, oils for cosmetics, paper pulps, biofuel etc. - Development of technologies for bio-polishing and biofinishing of diversified jute products using microbial enzymes. Achievements: - Isolated, purified and identified a good number of mesophilic and thermophilic microorganisms of both fungal and bacterial strains viz. <i>Trichoderma knningii</i>, <i>T. harzianum</i>, <i>Thermomyces lanuginosus</i>, <i>Bacillus amyloliquefaciens</i> etc. - Developed technology for up gradation of low grade jute and jute cuttings. - Development of process for biopulping using microbes and microbial enzymes. - Produced and analyzed lignocellulytic enzymes using selected thermophilic and mesophilic organisms. - Jute based microbial and biochemical processing technology has been patented and transferred to different jute industries for commercial utilization.
Pilot plant and processing Division	Objectives: - To perform pilot scale production of diversified jute products, entrepreneurship development and transfer of technology. - To utilize jute & jute waste for developing various products like pulp & papers, fuel cake etc. - To provide technical services/assistance to the cottage industries, jute industries in public and private sectors. Achievements: - Jute based sanitary napkin from absorbent cotton substitute. - Fire retardant process for jute fibre & fabrics. - Improvement of woolenization process and dyeing of the yarns. - Improvement of rot-proof process for production of hessian suitable for making nursery pot. - Production of sweaters from woollenized jute yarn. - Production of handmade paper from jute and jute waste. - Production & improvement of jute prayer mat. - Development of water repellent process for the jute fabric.

Target:

World population is mounting day by day. On the other hand cultivable land is decreasing gradually. With increasing trend of up growing population, world demand of jute and jute goods will increase progressively. Only high yielding variety and up scaling of production technology can mitigate these challenges. With these views in mind BJRI fixed a tentative target for jute production which are 60 lac bales, 65 lac bales, and 75 lac bales in the year 2015, 2020, and 2030, respectively.

Future Research

The area, production and average fibre yield of jute is shown in Figure-2 appears that area and total production are decreasing in trend but yield per unit area is increasing. This is happened due to dissemination of modern technologies in jute cultivation. Actually the modern varieties of jute and allied fibre crops were developed for ideal environment. On the other hand jute cultivation is shifting to the nontraditional field usually less fertile land due to pressure of food crops. There is a wide yield gap between national average and on station yield. So it is really hurdle for the growers to minimize the yield gap. With this idea in mind BJRI is trying to develop high yielding varieties for the stress environment and pay much attention to disseminate production technologies among the jute growers of the country.

4.2.4 Research Priorities

4.2.4.1 Agricultural Research

4.2.4.1.1. Research Agenda/Thematic Area: Genetic Resources and Seed Division

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Biotic and abiotic stress due to climatic change	1. Development of transgenic jute, kenaf and mesta varieties for biotic stress	60% jute growers	40	2	-	-	✓
	2. Development of transgenic jute, kenaf and mesta varieties for abiotic stress	50% jute growers	30	3	-	-	✓
	3. Molecular marker identification of jute, kenaf and mesta for marker assisted selection (MAS)	100% plant breeders	80	1	✓	✓	-
	4. Varietal development through marker assisted selection (MAS)	50% jute growers 100% for biotechnologist	40	3	-	✓	✓
Identification of good traits in JAF germplasm	Characterization and evaluation of JAF germplasm	100% jute researchers and ultimately jute growers	90	2	✓	-	✓

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Scarcity of JAF germplasm information	Documentation of JAF germplasm	70% researchers	80	1	✓	-	-
Erosion of JAF germplasm from home and abroad	Collection and conservation of JAF germplasm	100% jute researchers and growers	70	1	✓	-	-
Inadequate amount of JAF germplasm seed in the Gene Bank	Regeneration of JAF germplasm seed for conservation and distribution	90% jute researchers and growers	90	1	-	-	✓
Biotechnological research	1. Molecular characterization of jute, kenaf and mesta		80	1	*	✓	-
	2. Varietal development through marker assisted selection(MAS)	50% jute growers	40	3	*	✓	✓
	3. Gene construct and development	100%	60	3	*	✓	✓
	4. Development of transgenic jute, kenaf and mesta varieties for biotic stress	60% jute growers	40	2	*	*	✓

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
	5. Development of transgenic jute, kenaf and mesta varieties for abiotic stress	50% jute growers	30	3	-	-	√
Scarcity of for jute and kenaf seed	1. Production of quality jute and kenaf seeds through intercropping	60% jute and kenaf seed growers	60	1	√	√	-
Farmers reluctance for jute and kenaf seed production	1. Dissemination of BJRI jute and kenaf seed production technologies through demonstration	80% seed jute and kenaf seed growers	70	1	√	√	-

* Note: Need HRD and Lab development.

4.2.4.1.2. Research Agenda/Thematic Area(s): Plant Breeding (Varietal improvement of jute, kenaf and mesta)

Problem/ constraints	Research Title/ Key words	Beneficiary	Probability of success (%)	Priority ranking (1-3)	Research Tenure		
					Short	Med	Long
Lower yield of the previous varieties of jute, kenaf and mesta	Development of high yield varieties of jute, kenaf and mesta. Development of hybrid varieties of jute, kenaf and mesta.	100% Farmers 100% Farmers	80 50	1 2	√ -	√ -	- √
Changing of cropping pattern, lack of rainfall during sowing time and lack of fresh water for fibre retting	Development of early maturing and quick growing varieties of jute, kenaf and mesta.	100% Farmers	80	2	-	√	-
High photo-sensitivity (long day crop)	Development of day-neutral or photo-insensitive varieties of jute kenaf and mesta.	100% Farmers	50	3	-	-	√
Long duration of crop in the field against increasing cropping intensity Saline intolerance	Development of short duration varieties of jute, kenaf and mesta with high yield. Development of salinity resistant or saline tolerant varieties of jute, kenaf and mesta.	100% Farmers 10% Farmers	70 50	1 3	- -	√ -	- √
Highly susceptible to water logging condition (specially in tossa jute) Lack of vegetable variety in winter season	Development of abiotic/ physiological stress tolerant varieties of jute, kenaf and mesta. Development of vegetable varieties of jute, kenaf and mesta.	10% Farmers 10% Farmers	50 70	3 3	- √	- -	√ -

4.2.4.1.3. Research Agenda/Thematic Area(s): Agronomy (Soil & Fertilizer Management)

Problem/ Constraints	Research Title /Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short (S)	Med (M)	Long (L)
Absent of the recommendation of secondary and micro-nutrients for jute	Study the requirement of secondary and micronutrients on the production of jute.	50% Farmers	95	1	√	-	-
Need to assessment of fertilizer for new varieties	Study the nutrient of NPKS & Zn for newly developed bast fibre crops and seed.	100% Farmers	100	1	√	-	-
Low organic matter content of soil	Study the requirement and effect of conventional & non-conventional sources of organic matter on jute and allied fibre crop production.	50% Farmers	90	1	√	√	√
Depletion of soil fertility	Study the impact of integrated plant nutrient system on jute based cropping patterns and soil fertility.	100% Farmer	80	1	√	√	-
Yield potentialities are not achieved with the existing fertilizer recommendation	Updating of existing fertilizer recommendation for jute varieties in different AEZs.	100% Farmers	95	2	√	√	-
Gradually jute fields are being occupying by cereal crops	Development of jute based profitable cropping patterns.	60% Farmers	80	1	-	√	√

4.2.4.1.4. Research Agenda/Thematic Area: Agronomy (Crop Management)

Problem/ Constraints	Research Title /Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short (S)	Med (M)	Long (L)
Minimize yield gap	On farm participatory, research on maximization jute yields.	100% Farmers	70	1	√	√	√
Weed control	Chemical weed control.	50% Farmers	70	2	√	-	-
Minimize scarcity of quality seed	Experiment on high potential seed production.	100% farmers	70	1	√	-	-

4.2.4.1.5. Research Agenda/Thematic Area: Agronomy (Plant Physiology)

Problem/ Constraints	Research Title /Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short (S)	Med (M)	Long (L)
Less availability of stress tolerant genotypes	Screening for abiotic stress tolerant genotypes	Breeder-100%	50	1	√	√	√
Shorter period of jute seed viability	Development of technology for long term preservation of jute seed at farm level.	Farmer-80% BADC and others	80	2	√	-	-

Problem/ Constraints	Research Title /Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short (S)	Med (M)	Long (L)
Very short viability of kenaf and mesta seed	Extend of kenaf and mesta seed viability through biochemical intervention	Breeder- 20 Farmer- 80%	50	1	√	√	-
Dehiscent character of kenaf and mesta fruit	Screening for indehiscent character of kenaf and mesta fruit.	Breeder- 20 Farmer- 80%	50	3	√	-	-

4.2.4.1.6. Research agenda/Thematic area: Plant Pathology

Problem/ Constraints	Research Title/keywords	Beneficiary	Probability of success (%)	Priority ranking (1-3)	Research tenure		
					Short	Med	Long
No resistance sources available for resistant plant development against fungal disease of jute	Screening of germplasm for source of resistance to develop resistant variety	100% Breeders	50	1	√	-	-
	Conducting seed health test following ISTA	50% Farmers	80	1	√	-	-
	Mass production of biological control agent for controlling soil borne fungal pathogen.	100% Farmers	80	1	-	√	-
	Development of proper management package against fungal pathogen.	100% Farmers	90	1		√	-

Problem/ Constraints	Research Title/keywords	Beneficiary	Probability of success (%)	Priority ranking (1-3)	Research tenure		
					Short	Med	Long
Viral diseases: Lack of resistant variety and proper control approach against different viral diseases of jute and kenaf	Identification of effective seed treating and spraying fungicides for controlling seed borne pathogen of jute, kenaf and mesta.	100% Farmers	70	2	✓	✓	-
	Determination of residual effect of different pesticides for environmental protection		60	2	✓	✓	✓
	Assessment of yield loss against different fungal diseases.	100% Researchers	80	2	✓	✓	-
	Isolation and identification of toxins/enzymes responsible for disease development	100% researchers	70	3	-	✓	✓
	Identification of transmission mode of leaf curling and leaf yellowing of kenaf and mosaic of jute	50% Breeders 50 % Farmers	60	2	✓	✓	-
	Assessments of yield loss due to different viral diseases	100 % Farmers	90	2	✓	-	-
	Development of transgenic plant against leaf curling and leaf yellowing of kenaf and mosaic of jute	100 % Farmers	40	02	-	✓	✓
	Development of proper management approach against different viral diseases.	100 % Farmers	70	01	✓	✓	✓

Problem/ Constraints	Research Title/keywords	Beneficiary	Probability of success (%)	Priority ranking (1-3)	Research tenure		
					Short	Med	Long
Nemic disease: No resistant variety against nemic diseases of jute and kenaf.	Screening of germplasm for source of resistance to nemic disease	100 % Researchers	70	01	✓	✓	-
	Assessments of yield loss by different nemic diseases	100 % Researchers	90	02	✓	✓	-
	Soil amendments for controlling nemic diseases.	100 % Farmers	70	02	✓	✓	-
	Development of proper management approach against nemic diseases	100 % Farmers	80	02	✓	✓	-
	Evaluation of effective nematocide for jute and allied fibre crops.	100 % Farmers	70	02	-	✓	✓
Appearance of new disease (s)	Monitoring of occurrence of new disease pathotypes due to climatic change.	100 % Pathologists & Farmers	50	1	✓	✓	✓
Lack of information on residual effect of fungicide and namatocide on soil, air and water.	Assessment of residual effect of fungicide and namatocide.	100% Farmers	-	2	✓	✓	✓

4.2.4.1.7. Research agenda/Thematic area: Entomology

Problem/ Constraints	Research Title/keywords	Beneficiary	Probability of success (%)	Priority ranking (1-3)	Research tenure		
					Short	Med	Long
No resistant variety against apion and mite	Identification of sources of resistance against apion and mite	100% Breeders	60	1	✓	✓	✓
No resistant variety against spiral borer and mealy bug	Identification of sources of resistance against spiral borer and mealy bug	100% Breeders	60	1	✓	✓	✓
Lack of Bioecological information of newly appeared jute insect (cutworm, indigo caterpillar etc.)	Bioecological study of cutworm, indigo caterpillar etc.	50% Farmers 50% Researchers	70	2	-	✓	-
Lack of effective biopesticides.	Exploration of plant materials for controlling jute pest	100% Farmers	70	2	✓	✓	-
Lack of sufficient data on yield loss due to different insects and mite attack	Yield loss assessment of different varieties against different insect and mite.	100% Researchers	80	1	✓	✓	-
Non availability of	Mass production of <i>Apanteles oblique</i>	100% Farmers	60	3	-	✓	✓

Problem/ Constraints	Research Title/keywords	Beneficiary	Probability of success (%)	Priority ranking (1-3)	Research tenure		
					Short	Med	Long
Effective biocontrol agent against jute insect pest (hairy caterpillar semilooper, cutworm, indigo caterpillar)	Mass production of <i>Carcelia</i> sp.	100% Farmers	70	1	-	✓	✓
Lack of information on residual effect of pesticides on plant, water and soil	Assessment of residual effect of different chemical pesticides	100% Researchers & Planners	70	2	✓	✓	✓
Forecasting system of jute insect and mite pest is not available	Monitoring and forecasting of insect and mite pest of jute, kenaf and mesta due to climate change	100% Farmers	80	1	✓	✓	✓

4.2.4.1.8. Research Agenda/Thematic Area: Fibre Quality Improvement

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Limitation of better quality jute fibre production at farm level	Establishment of low-cost retting technique of jute/kenaf/mesta for quality up-gradation	50% of the jute growers	80	2	✓	-	-
Limitation of retting water	Isolation of hydrolytic and extracellular enzymatic microbes potential to jute retting. Establishment of preservation technique for extracellular enzymes promising to retting of jute/kenaf/mesta.	50% Jute growers	85	1	-	✓	✓
	Establishment of an appropriate media for long term preservation of jute retting bacteria.	50% Jute growers	80	1	-	✓	✓
	Preparation of fungal inoculums package for the acceleration of jute retting speed in water scarce jute retting areas.	90% Researchers	80	1	-	✓	✓
Prolonged retting time	Mechanizing of ribboner of green ribbon for quick retting	Farmers 50 %	80	1	-	✓	✓
Lack of awareness about the use of microbial inoculums	Demonstration training about the use of microbial inoculums package for retting jute/kenaf/mesta in water scarce areas of Bangladesh	Farmers 40 % 50 % Jute growers	90 90	1 1	- -	- ✓	✓ ✓

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Saline water management for retting of jute and allied fibre plants	Screening of different varieties of jute and allied fibre crops in different levels of water salinity	20 % of jute grower	70	1	-	√	-
	Assessment of surface water microbes for jute retting in coastal/saline areas of Bangladesh	10% of jute grower	70	2	√	-	-
	Adaptation of retting microbes in coastal/saline environments.	10% of jute grower	80	2		-	√
Lack of awareness of the jute growers about jute retting technologies and fibre grading	Dissemination of low cost retting technologies among the jute growers of Bangladesh.	50 % jute growers	90	1	√	-	-
	Dissemination of low cost retting technique of jute/kenaf/mesta for quality up-gradation.	50 % Jute/Kenaf/ Mesta growers	90	2	-	√	-

4.2.4.1.9. Research Agenda/Thematic Area: Fibre Technology Verification, Adoption, and Impact Studies on Jute and Allied Fibre

Problem/ Constraints	Research Title/ Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Fibre production cost and returns are changing in every year at farm level	On-farm socio-economic studies on jute production	80% Farmers and planners	90	1	✓	✓	✓
Farmers generally practice traditional cropping patterns with local variety and follow traditional cultural practices at farm level	Jute based cropping patterns studies in different agro-ecological regions	70% Farmers	90	1	✓	✓	✓
Non-availability of jute seed	On-farm jute seed production	60% Farmers	70	2	✓	✓	✓
There exists a wide variation in yield of JAF in the research station, on-farm trials and farmers traditional practice	Yield gap minimization through appropriate technology transfer in participations with farmers	70% Farmers	80	1	✓	✓	✓
Introducing newly developed HYV and improved cultural practices	Farmers training and field days and demonstration	80% Farmers	90	1	-	-	✓

4.2.4.2 Technological Research

4.2.4.2.1. Research Agenda/Thematic Area: Textile Physics Division

Problem/ constraints	Research Title/Keywords	Beneficiary	Probability of success %	Priority ranking (1-3)	Research Tenure		
					Short	Med	Long
Lower breaking twist Less extensibility, Brittleness of jute, Harshness of jute	Study the effect of breaking extension on yarn spinning	Jute spinning industry (100 %)	80	1	√	-	-
Hairiness of jute fabric	Study the effect of frictional intensity on yarn hairiness.	Jute spinning industry (100 %)	70	1	√	-	-
Hygroscopic nature of jute	To study the bonding behavior of fibre and polymer matrix in composite materials.	House hold and construction industries (80 %)	50	1	√	-	-
Less thermal and electrical insulation at moist weather	Determination of static charge and comfort properties of jute and jute related fabrics	Home Textile (85 %)	70	2	-	√	-

4.2.4.2.2. Research Agenda/Thematic Area: Chemistry Division

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Low light fastness of jute fabric	Development of integrated chemical wet processes for the improvement of dyeability of jute fabrics.	Jute industries (80 %)	90	1	√	-	-
Use of unhygienic synthetic dyes	Dyeing of jute with natural dyes.	Jute industries & local people (70 %)	90	1	√	-	-
Problem of raw jute	Studies on the various chemically modified jute fiber blended with other natural and synthetic fiber for diverse use in textile sectors without environment pollution.	Jute industries & Local people (65 %)	90	2	-	√	-
Limitation of modern technology	Carbon molecular sieve membrane prepared from jute lignin.	Jute industries (40 %)	60	3	-	-	√
Jute processing machinery	Investigation on jute and allied fibre materials as industrial raw materials to prepare chemical derivatives pulps and other non-woven products derivatives.	Jute industries & local people (40 %)	85	3	-	-	√
Inherent use of jute product	Development of textile finishing and proofing processes for jute products.	Jute industries (50 %)	70	2	-	√	-
Less use of jute product in textile product	Improvement of cost reduction of traditional jute products.	House hold & industries (50 %)	50	2	-	√	-

4.2.4.2.3. Research Agenda/Thematic Area: Jute Mechanical Processing

Problem/ Constraints	Research Title/Keywords	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Uniformity problem of jute yarns in jute industry	Introducing autoleveller in carding and drawing section of jute processing.	100% Jute Spinner	80	1	✓	✓	-
Irregular blending of jute fibre in jute industry	To manufacture fancy jute products using jute blended yarns for diversified uses and utilization as import substitutes for apparel fabrics.	100% Jute weaver/ Fashion Designer	90	1	✓	✓	-
Improved quality of fine jute yarn	To strengthen the research activities for this purpose. Production of fine yarn from jute in blends with other textile fibre by application of developed technology evolved with apron draft spinning frame.	100% Jute Spinner	95	1	✓	-	-
Jute processing machinery	Development of jute processing machinery through modification of existing machines and new innovation	100% Jute mills	70	1	✓	✓	✓
Jute processing techniques	Development of new technique for jute processing through optimization of machine parameters.	100% Jute products producer	80	2	✓	✓	✓
Jute based apparel and decorative fabric	Manufacture of value added jute fabrics of various designs and structures for apparel and decorative purpose.	100% Jute fabric manufacturer	70	1	✓	✓	-

4.2.4.2.4. Research Agenda/Thematic Area: Microbiology and Biochemistry (Improvement of jute fibre and products through microbiological and biochemical means)

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short (2015)	Med (2020)	Long (2030)
Non availability of effective microorganisms capable to produce cellulase, pectinase, xylanase etc.	Isolate and rearing effective microorganisms capable to produce cellulase, pectinase, xylanase etc.	Jute industry-60% Farmer-40%	80%	1	√	√	√
Availability of less efficient fermenting microbes	Development of highly efficient fermenting microbes through genetic modification.	Biofuel industry-80% General people-20%	70%	2	√	√	√
Non availability of eco-friendly softening enzymes	Development of cost effective technology for the production of eco-friendly softening enzymes from microbes.	Jute industry-100%	70%	1	√	√	√
Harshness of jute fabrics	Improvement of jute fabrics by applying enzyme.	Industry-50% General people-50%	60%	1	√	-	-
Lack of eco friendly technology for pulping	Bio-pulping of jute by using enzyme instead of harsh chemicals.	Industry-50% General People-100%	60%	1	√	√	-
Jute waste management	Usage of jute industrial waste through biochemical approach.	Industry-50% General people-50%	50%	2	√	√	√

4.2.4.2.5. Research Agenda/Thematic Area(S): Pilot Plant and Processing Division

Problem/ Constraints	Research Title/Key Words	Beneficiary	Probability of success (%)	Priority Ranking (1-3)	Research Tenure		
					Short	Med	Long
Low absorbent, Life time of jute fabric	Development of water repellent process.	House hold and industries (80%)	60	1	√	-	-
Starting problem for jute waste & scarcity of fuel	Processing of different types of jute waste for production of fuel cake.	Industries, local people (75%)	80	1	-	√	-
Limited resource for production of pulp & paper	To develop pulp paper from jute & jute waste.	Jute industries, and paper mills 80%	80	2	-	-	√
Limitations of modern technical application of dyeing.	Chemical modifications of jute and jute products.	Jute industries (70%)	70	2	-	√	-
Stiffness &discomfort properties of dyed jute fabric	Study on jute dying phenomenon with different types of dyes.	Jute industries,, Fashion designer (70 %)	80	1	√	-	-
Limitation of modern dyeing technology.	Studies on the fastness property of different dye stuffs for the improvement of fastness properties of union fabrics.	100% Jute fabric manufacturer.	80	1	√	-	-
Difficulty of production of jute based knit products.	Production of outer wears with jute woolenised yarn and study of its market feasibility.	Jute industry (80 %)	60	1	√	-	-

4.2.5 Opportunities

The importance of jute, the natural fibre is getting momentum globally due to aggressively growing consciousness about environment. Bangladesh could utilize this opportunity by producing more jute by expanding jute cultivation in the nontraditional area. There are some opportunities for promoting jute and allied fibre production and utilization by expanding some relatively tolerant to salt stress capsularis varieties and a kenaf variety in the saline belt. Another opportunity that ensure bulk use of raw jute is making paper pulp from green jute plant that also minimize the retting problem in the water scarce area. BJRI has developed a technology for producing lightweight shopping bag that could easily be popularized over the country and abroad. Besides these there are a number of technologies for producing eco-friendly jute goods which could be disseminated in the global market.

4.2.6 Conclusions and Recommendations

Jute is an industrial crop and grown in Kharif-1 season mostly under rainfed condition. The availability of retting water in time is becoming a limiting factor for producing quality jute and allied fibre. Due to global warming it is observed that the rainfall pattern is changing fast. So new technologies should be developed for utilizing whole jute plant in the jute growing areas where water is a limiting issue. As the global demand for natural fibre is increasing day by day and we have to sacrifice our good land for food crops, so the better option would be to explore the saline zones for jute and allied fibre crops cultivation. Another challenge is to produce and distribute quality seed.

4.3 Wheat

4.3.1 Introduction

Wheat (*Triticum aestivum* L.) was almost a nontraditional crop in this country up to early seventies. Bangladesh has become a wheat growing country by Mid eighties through a massive wheat production programme that initiated in 1975-76. A rapid dietary change of Bangladeshis brought wheat to prominence within a time span of only a decade. Wheat is rich in nutritional value than rice having high protein (12-14%), high fibre, minerals and vitamins. Wheat has very good industrial and commercial value due to its easy

utilization and marketing and about 50 items of food products are prepared from wheat. Wheat straw is durable and used for thatching purpose, cottage industries, as pulp for paper mills and feed for cattle. Wheat requires less water and can be grown with 1-3 light irrigation and in some case it can be grown in residual soil moisture. Wheat cultivation needs very less or almost no use of pesticides. Presently wheat is grown on 0.40 million ha that occupies 2.94 % of the total cropped area and 3.47 % of total cereal area. Currently Bangladesh is producing 0.96 million tonnes of wheat (30%) against the national demand of 3.0 million tonnes. The consumption rate of wheat is increasing at the rate of 3% per year. So, to meet up the demand Bangladesh needs to import at least 2.0 million tonnes of wheat grain every year.

About 85% of wheat is grown after harvesting T. Aman rice. Some of the important wheat based cropping patterns are:

- i) Wheat-Jute-T.Aman rice
- ii) Wheat-Mungbean-T.Aman rice
- iii) Wheat-Aus-T.Aman rice
- iv) Wheat-Fallow-T.Aman rice
- v) Wheat-GM-T.Aman rice, etc.
- vi) Wheat-Maize-T.Aman

Trends of Area and Production

The area, production and yield of wheat for the last 37 years (1972-2009) are shown in Figure 3. It appears from the Figure that during 1970-71 to 1980-81, wheat jumped from 0.126 million hectares to 0.591 million hectares and production increased from 0.11 million tonnes to 1.07 million tonnes hitting an impressive 24.93 percent annual growth rate. Tremendous growth in production during this decade came exclusively from expansion of modern wheat varieties and improvement of the average yield, which rose from 0.87 t/ha to 1.84 t/ha at 10.30% rate per annum. Such a spectacular success was possible due to joint effort of extension, research and BADC. A change in the dietary habit of the people also enhanced wheat production. The initial momentum, however, could not be sustained long. The annual growth rate of wheat area slowed to 1.1% during 1981-82 to 1993-94 and production remained virtually stagnant during this period. Stagnation was associated with various production constraints described later. Many wheat farmers of the

1970s switched to boro rice because of stable and higher yield, high market price and for food security. Wheat cultivation was gradually pushed to non-irrigated and marginal land. In the mid 1990s there was again a new momentum in wheat production. Both the area and production again started to increase and reached its highest peak in 1998-99. During this growing season, wheat was grown on 0.85 million hectares with a record production of 1.9 million tonnes, which is almost double of the production of 1980-81. The national average yield also continued to increase and rose to 2.3 t/ha in 1998-99. After that both area and production has started to decrease. The predominant variety Kanchan became highly susceptible to leaf blight diseases during this period which is one of the main reason for decreasing the area and production of wheat. Competition with Rabi crops like potato, maize, high value vegetables in winter is another reason for decline in area. During 2005-06, the production reduced to almost half of 1998-99. The disease *Bipolaris Leaf Blight* (BpLB) is relatively enhanced more due to less winter in the said years. However, with the development of several heat tolerant and disease resistant varieties the production became stabilized during last 4 years. In the last year (2008-09) the average yield was 2.15 t/ha with a production of 0.85 million tonnes from 0.395 million hectare (BBS, 2008).

4.3.2 Constraints

It is revealed from the above analysis that wheat has continuously declined from 1998-99 and both area and production reduced to half in 2008-09. The average grain yield in past 9 years was around 2.0 t/ha with the exception of 2004-05 and 2005-06 when the average yield was dropped to 1.75 and 1.53 t/ha, respectively, due to higher temperature during grain filling period and high incidence of BpLB in the predominant variety Kanchan. However, the average yield of varietal demonstration trials during last few years at farmers' field was 3.0 t/ha. The mean yield of new varieties so far recorded at research stations with optimum management is 4.0 t/ha. The low yield at farmers' field, and decline in area and production of wheat was due to various biotic and abiotic constraints and crop competition which are discussed below:

A. Biotic constraints

Wheat Research Centre (WRC) of BARI so far developed 24 varieties out of which 18 became susceptible to major wheat diseases and six varieties released since 1998 are tolerant/resistant to major wheat diseases, especially leaf blight and leaf rust diseases.

Diseases:

- (1) **Bipolaris leaf blight (BpLB):** Leaf blight or spot blotch caused by *Bipolaris sorokiniana* (Sacc. in Sorok) is the most destructive disease of wheat in the rice-based cropping systems in Bangladesh. It may cause moderate to severe yield losses (10-40%) depending on the variety, time of sowing and agronomic management. Infected seed is the primary source of inoculum of this disease. The inoculum may also survive in the soil, crop residue and some other crop and weed species, particularly those belonging to gramineae family. Severity of the disease increases rapidly after flowering, particularly if warm and humid conditions prevail. So, severity of this disease is high in case of late seeded crop. Resistance to this disease is additive in nature and controlled by a few or polygenes with small effects and this makes breeding for resistance a difficult task. The cultivated varieties do not have high degree of resistance against the disease. However, there are variations among the genotypes in degree of disease severity. BARI developed new wheat varieties have moderate to good level of tolerance to this disease. Fungicidal seed treatment with Provax and foliar spray with Tilt can reduce the incidence of this disease.

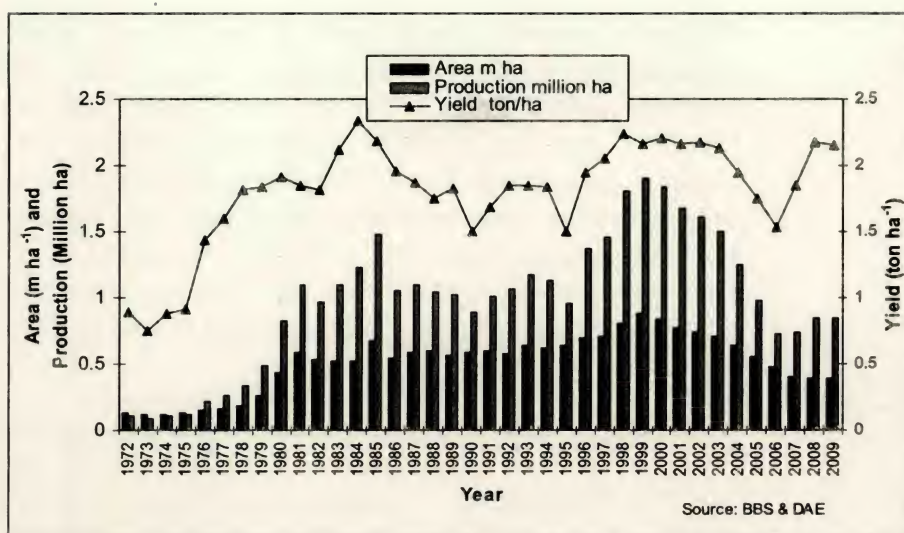


Figure 3 Area production and yield of wheat, 1972-2009

- i) **Leaf rust:** Leaf rust caused by *Puccinia triticina* Eriks. (= *Puccinia recondita* f. sp. tritici) is considered as the second most important disease of wheat in Bangladesh. Yield losses are usually small, but can be severe if a susceptible variety is grown and infection occurs early in the crop season. In collaboration with wheat programme in CIMMYT-Mexico and India, six major leaf rust resistance genes have been identified in the cultivars and advanced lines of Bangladesh. The resistance genes are Lr1, Lr3, Lr10, Lr13, Lr23 and Lr26, which have occurred either singly or in combination of two genes along with some unidentified factors for resistance. A slow rusting gene Lr34 is also present in few lines and varieties. New wheat varieties such as Sourav, Gourab, Shatabdi, Sufi, Bijoy and Prodip are resistant to the existing leaf rust population in Bangladesh.
- ii) **Black point:** Black point of wheat is a disease of grain. It is considered as a major problem for production and marketing of wheat seed. In order of prevalence, the major fungi associated with the black point disease are *B. sorokiniana*, *Alternaria alternata*, *Curvularia lunata*, *Fusarium* spp. and *Cladosporium cladosporioides*. Severity of the disease increases if rain occurs or humid

condition prevails during grain filling period. Seed germination is reduced depending on severity of infection, particularly when *B. sorokiniana* and/or *Fusarium* spp. are involved. At present, none of the varieties or advanced lines is completely free from black point infection but variability in degree of disease incidence exists among the genotypes. Occurrence of black point may be avoided to a large extent if the crop is harvested (without delay after maturity) before rain or humid weather.

- iii) **Head blight:** Head blight or ear-head infection caused by *B. sorokiniana* is becoming an important disease of wheat in Bangladesh. It usually affects one or more spikelets of an individual ear-head. Severely infected spikelets do not bear any seed inside the florets. The disease is favoured by warm and humid weather during and after heading. None of the cultivars and advanced lines has been found to be completely free from the disease, but considerable variability in incidence of the disease exists among them. Spraying with Tilt 250 EC (0.05%), once at heading and another at 15 days later, can minimize the incidence of the disease. Studies have been initiated to generate detail information on this disease.

Insect pests:

- i) **Insects:** Attack of insects remains a minor problem for wheat production in Bangladesh. Aphid, stemborer, wireworm, shoot fly, grasshopper, hairy caterpillar, stinkbugs and termite are found at different growth stages of wheat but their population is low to cause any significant yield loss. However, regular field monitoring is being conducted to assess potential damage caused by insect-pests.
- ii) **Rodents:** Rats cause serious damage to the crop throughout the growth period. Necessary measures should be undertaken to control the rats from the beginning. Rats could be controlled by using poison baits, traps, water, smokes, etc.

- iii) **Birds:** Birds causes seed and seedling damage up to 10-12 days after sowing and reduces the plant population to a greater extent. Measures should be ensured to drive out the birds up to 10-12 days after seeding to avoid the seed and seedling damage by birds.

B. Abiotic constraints

- i) **Heat stress:** High temperature is one of the major constraints of wheat production in Bangladesh. Increasing temperatures usually hasten crop development and shorten the grain filling duration, which severely reduces grain yield. Late sown wheat is more affected by heat stress.
- ii) **Late planting:** About 60% wheat area is planted late due to late harvest of T.Aman rice, shortage of labourers, less availability of draught power, etc. Wheat crop is exposed to high temperature during grain filling period causing force maturity, shriveling of grains and significant yield loss. The yield of wheat reduces at the rate of 1.3% per day when sown beyond optimum time (November 15-30).
- iii) **Drought stress:** Water scarcity for irrigation is very common in many areas of Bangladesh and ground water table is rapidly declining. Even irrigated wheat is facing temporary drought stress in critical growth phases like tillering, booting and grain filling that reduces wheat yield.
- iv) **Water logging:** Wheat plants can not withstand water logging at seedling stage especially at crown root initiation stage. Over irrigation at first irrigation followed by rain may cause water logging. It causes yellowing of leaves and stunted growth and low yield.
- v) **Sterility:** Sterility frequently occurs in the light soil of northwestern part of Bangladesh causing significant yield loss in some years. Sterility is presumed to be associated with low soil fertility, especially deficiency of boron. Although some environmental factors such as low light intensity, high humidity, foggy weather at anthesis is likely to enhance the sterility problem.

- vi) **Soil acidity:** In light textured and acidic soils with pH 4.5-5.0, liming with calcium carbonate @ 2 t/ha was found most effective. Application of lime with recommended fertilizers gives 20% more yield of wheat in first year and 15% in the subsequent years over control. It also increases the soil pH and availability of soil nutrients specially P, Ca, Mg and B.
- vii) **Salinity:** It is a major constraint of expanding wheat in southern region where salinity during sowing time vary from 3.0 to as high as 15 ds/m. Most of the wheat varieties can tolerate salinity level of 6-8 ds/m at seedling stage.
- viii) **Sub-optimal use of fertilizers and inappropriate urea management:** Survey results from farmer's field showed that about 50% farmers are not using recommended doses of fertilizers. Sub optimal use of fertilizers reduces wheat yield significantly and is the major cause for low yield at farm level. Moreover, most of the farmers do not apply urea as per recommendation.
- ix) **Poor plant establishment:** It has been observed that proper plant establishment is not found in many farmers field though they use recommended seed rate. The reasons may be associated with low viability of seed from farmers' storage, low soil moisture at planting, damage of seedlings by seed and soil borne pathogens and insects like wireworm, etc.
- x) **Other agronomic practices:** Most of the farmers give over irrigation to wheat fields and do not ensure proper drainage. Over irrigation often creates water logging and cause injuries to the seedlings and enhances sterility. Weed in wheat field causes 15-20% reduction of wheat yield. Majority of the farmers are reluctant to clean weeds, which causes significant yield loss.

4.3.3 Research Progress

Keeping all the above factors in view WRC, BARI has been conducting research to generate suitable technologies for the farmers not only to sustain the wheat production but also to enhance wheat

productivity by minimizing the yield gap at farm level. Some of the important achievements are highlighted below:

Division/ Discipline	Technology Generated
Genetic Resources	Every year about 200-500 wheat germplasms are received from CIMMYT in the form of nurseries and trials. These lines are usually evaluated against different biotic and abiotic stresses and characterized for different traits. So far 250 germplasms are being maintained regularly through germplasm observation nursery and crossing block and utilized by the breeders for developing varieties with desired traits.
Breeding Division	The overall objective of variety improvement programme is to develop high yielding semi-dwarf varieties having white amber bold grain and resistant/tolerant to biotic and abiotic stresses. Achievements • Wheat Research Centre of BARI has so far released 24 varieties for commercial cultivation. Among those, Sonalika released in 1973 and Kanchan released in 1983 became the most popular. • BARI released 6 high yielding varieties: BARI gom 19 (Sourav) and BARI gom 20 (Gourab) in 1998, BARI gom 21 (Shatabdi) in 2000 and BARI gom 22 (Sufi), BARI gom 23 (Bijoy) and BARI gom 24 (Prodip) in 2005. These varieties can yield 3.5-5.2 t/ha depending on the growing environment. They are early to medium in maturity (105-112 days), semi-dwarf type with white amber grains. Among these, Sufi and Prodip possess strong gluten and suitable for bread making. All the six varieties are moderately tolerant to terminal heat stress and resistant/tolerant to leaf rust and leaf blight diseases. • Two new varieties (BAW 1059 and BAW 1064) with high yield potential are waiting for release in 2010.
Disease management	• Seed treatment with Provax-200 @ 3g per kg of seed enhances seedling vigour and increases plant population by 15-20% and grain yield by 10-12%. • Spraying of Tilt 250 EC @ 0.50 ml per litre of water at anthesis and 15 days after anthesis can control leaf blight disease.

Division/ Discipline	Technology Generated
	- Seed treatment with Provax 200 WP @ 3 g/kg of dry seed effectively controls black point fungi thereby improving germination and yield. Spraying with Tilt 250 EC (0.05%) at heading and 15 days later reduces severity of black point. - WRC identified a good number of genotypes having tolerance to leaf blight disease which are being used in hybridization programme. - A good number of genotypes have been identified to be resistant to leaf rust. In addition, few high yielding lines showed moderately resistant reaction against stem rust race Ug99 in Kenya through shuttle breeding.
Soil and Crop Management	- Optimum time of wheat sowing is Nov 15-30, sowing beyond optimum time reduces wheat yield @ 1.3% per day delay i.e. 44 kg /day/ha. - First irrigation at 17-21 days after seeding (i.e. at CRI stage), 2nd irrigation at heading time and 3rd irrigation at 70-75 days after sowing (early grain filling stage) are recommended. Only first irrigation increases wheat yield by about 43%. - Weed control after 1st irrigation or within one month by hand or herbicide increases wheat yield by 15-20%. - Application of boron @ 1.0 kg per ha ((Borax 10 kg or Boric acid 6 kg per hectare) in B deficient soil with recommended NPKS fertilizers combat sterility, enhances wheat yield by 10-15%. Use of cowdung/compost (2-10 t/ha) is also suggested to use along with the recommended fertilizers. - Use of dolochun a dolomite lime $[CaMg(CO_3)_2]$ in low pH soil at every 3 years @ 1-2 t/ha depending on soil pH enhances the availability of P and increases wheat yield by 15-20%.
Mechanization	- Development and dissemination of power tiller operated seeder (PTOS) in rice-wheat system. This seeder performs tilling, seeding in rows, and covering seed simultaneously in a single pass. It minimize turn around time and production cost. - Design and development of seed cum fertilizer zero till drill. This drill performs seeding and fertilizing at a time. Most of the crop can be sown including

Division/ Discipline	Technology Generated
	wheat.
	- Design and development of power tiller operated bed planter. It can perform bed formation and seeding operation in a single pass. This planter also allows seeding on permanent bed without breaking the previous bed. This system facilitates efficient irrigation, less lodging of crop, minimum rat damage and satisfactory yield. - More than 300 operators, advanced growers, agricultural officers, NGOs are trained on operation, maintenance and trouble shooting of these resource conservation technologies (RCTs).

Future Production Target

To meet the demand of the growing population, every year more than 2.0 million tonnes of wheat grain is being imported at the cost of huge amount of foreign currency. Therefore massive production programme needs to be implemented in collaboration with WRC, BARI, DAE, BADC, NGO, etc. The technology adoption process also needs to be strengthened. Considering the above scenario, production target up to 2030 may be fixed as shown in the following table:

Table 8. Production target in 2010, 2015, 2020, 2030 (as far as available)

Projected population/Demand/ Production target of wheat	Projected Year			
	2010	2015	2020	2030
Projected pop. (million)	148.0	156.7	166.9	190.6
Demand (million tonne)*	2.99	3.16	3.37	3.85
Target area (million ha)	0.40	0.45	0.50	0.55
Target avg. yield (t/ha)	2.40	2.60	3.00	3.40
Production target (million tonne)	0.96	1.10	1.43	1.88

*Considering per capita consumption @ 55.28 g per day (20.18 kg/capita/year)

* Production in 2008-09 was 0.85 million tonne; Population growth rate: 1.39%

Source: BBS and Ministry of Agriculture

4.3.4 Research Priorities

4.3.4.1. Research Agenda/Thematic Area-1: Genetic Resources and Variety Improvement

Problems/ constraints	Research Title/Key words	Beneficiary	Probability of success (%)	Priority Ranking	Research Tenure	
					Long	Short
Collection, conservation, documentation & evaluation of germplasm	Collection, characterization, documentation of more germplasm. Evaluation against biotic and abiotic stresses to identify resistant genes for utilizing in variety development	60 % Researchers	75	1	✓	✓
Development of diseases resistant varieties	Resistant varieties against leaf rust, leaf blight and black point diseases with high yield potential	100 % Farmer	80	1	✓	✓
Late plantating, heat tolerant varieties	Early maturing heat tolerant variety with high yield potential	65 % Farmer	80	1	✓	✓
Drought & saline tolerant varieties	Develop varieties for drought, water logging and saline areas.	45 % Farmer	60	1	✓	✓
Micronutrient efficient variety	Screening for B, Mo, Zn efficient genotypes.	40 % Farmer	60	2	✓	-
	Breeding varieties for improved nutritional quality (High protein, minerals)	65 % Farmer	80	2	✓	*

4.3.4.2. Research Agenda/Thematic Area: Biotechnology

Problems/ Constraints	Research Title/Key words	Beneficiary	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
IPR protection, future release of varieties	Molecular characterization (finger printing) of varieties	Country as a whole	100	1	√	√	*
	Marker Assisted Selection to identify and tag molecular markers for leaf rust and stem rust disease	65 % Researchers and Farmers	75	1	√	√	*
	Gene mapping for particular trait	60 % Researchers	60	2	√	√	*
	Haploid breeding through wheat-maize crossing following embryo rescue	60 % Researchers and Farmers	70	2	√	√	*

Note: * Development of Lab facilities and HRD

4.3.4.3. Research Agenda/Thematic Area: Diseases and Pest management

Problems/ constraints	Research Title/Key words	Beneficiary	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
Identify sources of diseases resistance	Screening of genotypes under artificial epiphytotic and field conditions for major wheat diseases like leaf blight, leaf rust, etc.	100 % Breeders	65	1	✓	✓	✓
Monitor appearance of new diseases traced	Survey and monitoring for new diseases and new races, especially Ug 99.	65 % Wheat programme	60	1	✓	✓	✓
	Identify pathogenic races using molecular technique	60 % Researcher	65	1	✓	✓	*
Control of diseases	Cultural, chemical and integrated control of major diseases	100 % Farmers	75	2	✓	✓	✓
Insect pests	Regular field monitoring to assess potential damage caused by insect-pests.	60 % Wheat programme	75	1	✓	✓	-
Control of insects, if any	Develop management package if any insect cross threshold level	20% Farmers	80	1	✓	✓	-
	Rat control for southern belt	20 % Farmer	80	1	-	-	✓

4.3.4.4. Research Agenda/Thematic Area: Crop Management

Problems/ constraints	Research Title/Key words	Beneficiary	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
Stress management	RCTs to manage heat, drought, salinity through straw retention and maintaining residual soil moisture.	70 % Farmers	80	1	✓	✓	✓
Improve soil fertility	Develop cropping pattern to avoid late planting of wheat and to sustain and improve soil fertility Microbial decomposition of wheat straw	65% Farmers 50% Farmers	75 80	1 1	✓ -	✓ ✓	✓ ✓
Ground water depletion	Efficient irrigation scheduling	65% Farmers	75	1	✓	✓	✓
Yield gap reduction	Refine improved management packages for high yield through farmers participatory research	60% Farmers	70	1	✓	✓	✓
Climate change	Climate change adaptation (e.g. heat, drought, salinity) through improved crop management.	70% Farmers	80	1	✓	✓	✓
GIS mapping	GIS mapping of suitable areas for wheat Thermal zoning maps	100% Researchers, Planners and Farmers 60 %	80 80	1 1	✓ ✓	✓ ✓	✓ ✓

4.3.4.5. Research Agenda/Thematic Area: Farm Machinery

Problems/ constraints	Research Title/Key words	% of beneficiary	Probability of success (%)	Priority Ranking	Research Tenure	
					Long	Short
Labour shortage and minimize turn around time	Small scale farm machinery (PTOS, reaper, bed planter) should be improved	60 % Farmers	75	1	✓	✓
	New entrepreneur should be developed to enhance fabrication of machinery	65% Manufacturers and Farmers	75	1	✓	-
Resource conservation technology	Development of seed processing equipment for quality seeds production.	60% Farmers	70	2	✓	-
	Water resource management and promotion of water saving technologies	70% Farmers	80	1	✓	✓
	Enhancing farmers' income through introduction of resource conservation technologies (RCTs).	70% Farmers	80	1	✓	✓
	Development of light weight farm machinery for the reduction of drudgery to farm women.	60% Women labourers and Farmers	75	2	✓	-

4.3.4.6. Research Agenda/Thematic Area: Seed technology and Nutrition

Problems/ constraints	Research Title/Key words	Beneficiary	Probability of success %	Priority Ranking	Research Tenure		
					Long	Med	Short
Seed quality & storage	Seed quality research, seed size, seed viability loss etc at farmers' level	60 % Farmers	70	1	-	✓	✓
	Mechanization for seed grading, packing etc.	20 % Businessmen		2	✓	✓	-
	Strengthening maintenance breeding programme to produce more breeder seed.	65 % Farmers	80	1	✓	✓	✓
	More diversified and nutritional food products should be prepared using wheat and other food crops.	60% Consumers	70	2	✓	✓	✓
	Screen for high quality varieties (protein, mineral)	50% Consumers	65	1	✓	V	✓

4.3.5 Opportunities

The area, production and average grain yield are shown in Figure 3 appears that both area and production almost reduced to half during 2008-09 compared to 1998-99. On the contrary, the wheat consumption is increasing every year. So, every year huge quantity of wheat is being imported to meet the national demand. Therefore, appropriate wheat research and development program should be undertaken to sustain and increase wheat production in the country.

Vertical Expansion

At present there is huge yield gap between potential yield and farmers' average yield. Last year (2009) national average yield was only 2.18 t/ha, while the demonstration average yield during last several years is 3.0 t/ha. Therefore, national average yield could be raised to 3.0 t/ha quite easily by adopting the following measures:

- Quick dissemination of new high yielding varieties to the farmers;
- Extensive farmers training on modern wheat production and seed preservation technologies and participatory demonstration;
- Small scale mechanization should also be given emphasis to enhance wheat productivity in the country through timely operation.

Horizontal expansion

The scope of expanding wheat in traditional wheat area is very difficult. However, a vast area remains fallow in winter in southern region and Sylhet. Moreover, Barind area of Rajshahi region is a very dry area where about 70,000 ha land is lying fallow due to moisture stress during winter every year. In future, availability of water for irrigation will be severely reduced due to global climate change and depletion of ground water. So in this region boro rice should be replaced by wheat and the short duration aman rice should be introduced in this area for planting wheat in normal time.

Therefore, wheat could be introduced in part of the areas with limited/light irrigation or with residual soil moisture. In that case, high yielding disease resistant varieties well adapted to the stress situations like heat, drought, salinity, etc. will be required in future.

4.3.6 Conclusion and Recommendations

From the above mentioned facts and figures it is revealed that global climatic change will affect wheat production unless necessary measures are well taken. Among the biotic factors, new races of diseases may become more virulent. Intensity of abiotic stresses like heat, drought, salinity, etc. will be enhanced affecting the productivity of wheat in future. Availability of land will also be reduced due to urbanization. Due to climate change in future there will be scarcity of water during wheat season and crop will be exposed to more frequent drought. To keep pace with future demand of wheat, vertical expansion through improving wheat productivity is more feasible than horizontal expansion. However, there are some scopes to increase wheat area in southern belt, in Sylhet area and in barind area where thousand of hectares of land remain fallow during winter.

Therefore, the following recommendations may be considered to sustain and increase wheat production in Bangladesh.

- Senior and experienced wheat scientists are retiring every year. So human resource development programme should be continuous process in future. Well trained scientists and well equipped lab facilities are prerequisites to start biotechnological research. In this regards collaboration with CIMMYT should be further strengthened.
- Water table is going down every year; annual precipitation is also reducing due to global climatic change. So, water is going to be scarce commodity in future. Wheat may become the alternative source of cereal in place of boro rice as wheat requires much less water than rice.
- Since, there is very high crop competition in traditional wheat area; wheat can be expanded in barind area of Rajshahi, southern belt and greater Sylhet district, where abundant land remains fallow in the winter.
- Collaborative research work with CIMMYT in special fields like breeding varieties for salinity, drought, heat, etc. should be strengthened.
- Participatory adaptive research in farmers' field should be strengthened for upscaling of technologies and reduce yield gap.

4.4 Maize

4.4.1 Introduction

Maize is the 3rd most important cereal after wheat and rice and plays a significant role in human and livestock nutrition worldwide. About 75% of maize is fed to animals, thus, indirect consumption is greater than direct consumption. Although 68% of the global maize area is in the developing world, but it contributes to 46% of the total global production. The average yield of the developed world is 8 t/ha and that of developing world is around 3 t/ha (FAO Website).

Maize in Bangladesh is becoming an important crop in the rice based cropping system. Currently about 1 million tonnes of maize is produced in the country in around 0.15 million ha of land. The area, production and yield steadily increased since the introduction of hybrid maize in 1993 by the private sector as shown in Figure 4. This is due to favourable growing conditions (no serious constraints) during the main maize growing season (October - March) and use of hybrid seeds and improve cultivation practices. Maize productivity in the country (5.5 t/ha) is the highest in Asia. It is mostly fed to poultry, fish and animals as well as consumed to some extent by people mixing with wheat flour, and pop corn in Bangladesh. The annual demand now is about 1.8 million tonnes of which about 50% is imported.

Maize is grown almost throughout the country. But major concentrations are in the northwest part, Jessore region, Dhaka (Savar) and Comilla region. The major cropping patterns involving maize are –

- Aus rice – T. Aman rice – Maize
- Maize – Mungbean – T. Aman rice
- T. Aman rice – Potato + Maize
- Potato – Maize + red amaranth – T. Aman rice
- Maize – Jute – T. Aman rice
- Maize – Fallow – T. Aman rice

Maize is a versatile crop, every parts of which is utilized. Grain is used as feed and food, green leaves and stalks are used as fodder for cattle, after threshing the rachis, husks and dried stalks are used as fuel which is becoming a scarce commodity in Bangladesh.

4.4.2 Constraints

A. Biotic Constraints

Disease:

In Bangladesh so far 28 diseases have been reported in maize of which 19 diseases are caused by fungi, one by bacteria, 3 by virus/micoplasma and 5 by nematode. Although diseases are not a serious threat till now but the following diseases are commonly observed.

- Leaf blight (*Turcicum of Maydis*)
- Downey mildew
- Sheath blight
- Black karnel rot
- Ear rot
- Stalk sot

Some of these diseases are caused by a complex of more than one fungus.

Insect pests:

Fifteen insect pests have been noted in maize in Bangladesh. But their occurrence is much below the threshold level and no control measure is necessary yet. The insects most likely occur as key insects in future are –

- Cutworm (*Agrotis ipsilon*)
- Stem borer (*Sesamina inferens and Chilo partellus*)
- Corn earworm (*Helicoverpa armigera*)
- Maize aphids (*Ropalosiphum maidis*)

B. Abiotic constraints

Soil Nutrient deficiency:

Bangladesh soils are in general deficient in nutrients. But some of the nutrient deficiencies are wide spread and below critical levels especially for maize for which conspicuous deficiency symptoms appear in plants and often those are confused with disease symptoms. For instance Mg, Zn and B deficiency are a common phenomena in the northwestern Bangladesh which is the most concentrated area of maize in

the country. These deficiencies can reduce maize yields substantially.

Hail-storm and Rain & High Humidity In Khaif-1 season:

Many times the maize planted in kharif-1 season i.e. February/March is hit by hail-storm and northwester in April/May which cause physical damage of plants and leaves and cause lodging and as a result yield is drastically reduced. The high humidity, rain and cloudy weather during harvest in May/June create problems for drying and threshing of cobs. When these cobs are stored the seeds are damaged due to fungal attack. Sudden torrential rain may cause water stagnation in maize field and if it lasts for 3/4 days the plants become yellow and plant growth is stunted resulting poor yield. Therefore, rabi season is better for maize to avoid these problems.

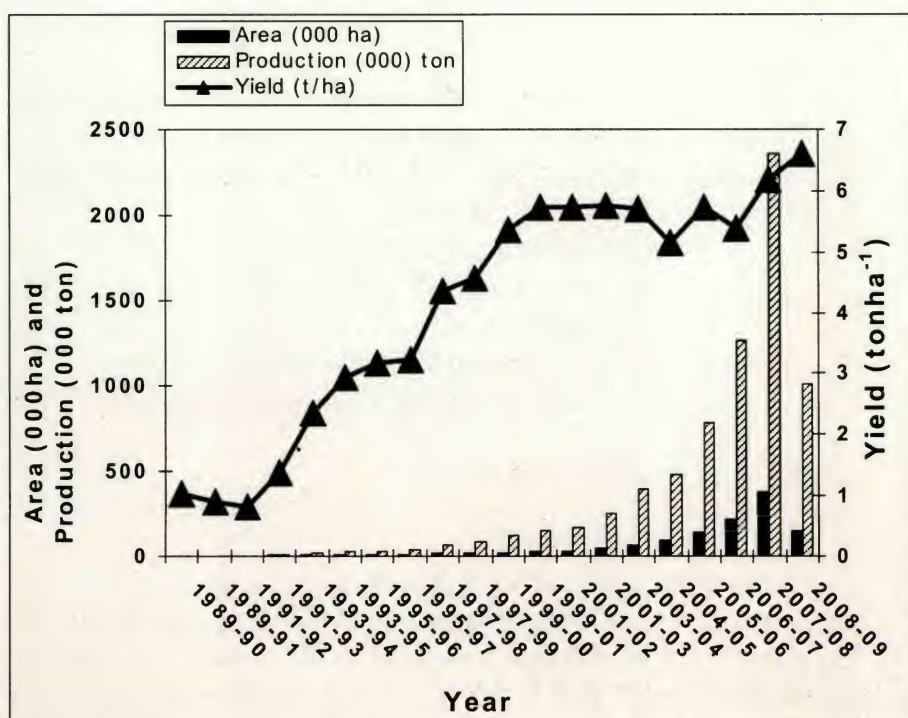


Figure 4 Area, production and grain yield of maize in Bangladesh (1990-2009)

4.4.3 Research Progress

BARI has been conducting research to generate suitable technologies for the farmers not only to sustain the maize production but also to enhance maize productivity by minimizing the yield gap at farm level. Some of the important achievements are highlighted below:

Division/ Discipline	Technology Generated
Genetic Resources	Every year about 100-150 maize germplasms (inbred and hybrids) are received from CIMMYT (Mexico and India). These hybrids and inbred are usually evaluated at different agro ecology of Bangladesh and characterized for different traits. So far 250 inbred lines were being maintained regularly and utilized by the breeders for developing hybrid varieties with desired traits. The work will continue in future to collect and evaluate more germplasms against various stresses and diseases to identify tolerance/ resistance sources.
Breeding Division	Achievements • BARI so far developed 19 varieties and disseminated in the farmers' field. Among those, 8 varieties were OP including one popcorn and one sweet corn variety during 1986-2002. After that BARI released 11 hybrid maize varieties from 2000 to 2008. Among the hybrid varieties BARI hybrid maize-5 is quality protein maize (QPM). The yield potentiality of these varieties 8.5-11.5 t/ha depending on the growing environment. • One new white grain hybrid variety with high yield potential is waiting for release in 2010.
Fertilizer recommendation	Fertilizer dose for the popular hybrids (including BARI hybrids) has been recommended for different AEZ of the country.
Liming	Liming with dolomite @ 2 t ha ⁻¹ followed by boron application @ 3.0 kg ha ⁻¹ along with N ₃₀₀ P ₅₀ K ₁₂₅ S ₂₀ Zn ₄ kg ha ⁻¹ was found suitable for maximizing the yield of hybrid maize under AEZ 3. Dolomite lime gave 12% higher yield over calcite lime.
Boron deficiency	Boron @ 2 kg ha ⁻¹ was found as optimum along with the blanket dose of N ₃₀₀ P ₅₀ K ₁₂₅ S ₂₀ Zn ₂ kg ha ⁻¹ for maize (cv. Pacific 11), N ₂₀ P ₁₅ K ₁₆ kg ha ⁻¹ for GM

	crop and $N_{120}P_{35}K_{65}S_{20}Zn_4$ kg ha ⁻¹ for <i>T. aman</i> rice for maximizing the yield of the said cropping pattern. Boron should be applied once to the first crop (maize)
Yield increase	Liming with dolomite (@ 2 t ha ⁻¹) should be done at least one month before seeding at every three years interval. Boron (@ 2.0 and 2.5 kg ha ⁻¹ for Patgram and Lalmonirhat, respectively) along with a blanket dose of $N_{300}P_{50}K_{125}S_{40}Zn_2$ kg ha ⁻¹) should be applied for maximizing the yield of hybrid maize (cv. BARI Maize – 5) in the study area.
Deep tillage	Deep tillage was found beneficial in reducing bulk density, particle density and infiltration and in improving porosity and field capacity. Irrigations maintaining IW: CPE ratio of 1.0 along with deep tillage was found suitable for maximizing the yield of hybrid maize where irrigation played major role in augmenting yield.
Irrigation	Four irrigations at the moisture regime of IW/CPE ratio 0.6 gave highest yield. Water deficit at flowering and grain filling stage must be avoided.
Intercrop with maize	Intercropping of pea, red amaranth coriander, bush bean, sweet potato, carrot, groundnut, spinach with hybrid maize and relay cropping of maize with potato gave high maize equivalent yield and high benefit (3.0-4.25) cost ratio than the sole crop.
Insect and Disease management	Disease and pest remain below threshold level in almost every year.
Agricultural Machinery	Maize sheller developed

Future Production Target

The area, production and average grain yield are shown in Figure 4. It appears that area, production and yield are increasing exponentially. Therefore, appropriate maize research and development program should be undertaken to sustain and increase the maize production in the country.

- At present there is yield gap between potential yield and farmers' average yield. Last year (2009) national average yield was only 5.30 t/ha, while the demonstration average yield during last several years was 10.0 t/ha. Therefore, national average yield could be raised to 7.5-8.5 t/ha quite easily by transferring the appropriate technologies to the farmers. Small scale

mechanization should also be given emphasis to enhance maize productivity in the country.

Table 9. Production target in 2010, 2015, 2020 and 2030 (as far as available)

Projected population/Demand/ Production target of maize	Projected Year			
	2010	2015	2020	2030
Projected pop. (million)*	148.0	156.7	166.9	190.6
Demand (million tonne)	1.88	2.25	3.00	3.50
Target area (m ha)	0.20	0.30	0.35	0.35
Target avg. yield (t/ha)	6.5	7.5	8.0	8.5
Production target (milmmillion. tonne)	1.30	2.25	2.80	2.97

Source: BBS and MoA

Therefore, maize production could be easily expanded up to 0.35-0.40 m ha with a target of 3.0-3.6 Mt of maize grain through a massive production program. The technology adoption process also needs to be strengthened. Considering the above scenario the research thrust should be given in the following priority areas within each discipline.

4.4.4 Research Priorities

4.4.4.1. Research Agenda/Thematic Area: Genetic Resources and Variety Improvement

Problems/ Constraints	Research Title/Key words	Beneficiary (%)	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
	Collection of more inbred and hybrids Characterization and documentation Evaluation against different stresses to identify resistant genes Utilizing new sources of gene in developing new inbred lines and hybrid varieties	60	75	1	✓	✓	✓
	Development of high yielding, QPM white hybrid maize variety for human consumption.	80	80	1	✓	✓	✓
	Develop varieties for drought, water logging tolerant and for saline areas especially for kharif season.	65	75	1	✓	✓	✓
	Screening for B, Mg, Mo, Zn efficient inbred and hybrids.	60	70	2	✓	✓	-
	Breeding varieties for improved nutritional quality.	65	80	2	✓	✓	-
	Disease resistant varieties for leaf blight and ear rot, downy mildew diseases with high yield potential.	70	80	1	✓	✓	✓
	Development of pop corn and sweet corn hybrids	50	75	1	✓	✓	✓

4.4.4.2. Research Agenda/Thematic Area: Biotechnology

Problems/ constraints	Research Title/Key words	Beneficiary (%)	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
	Molecular characterization (finger printing) of varieties and inbred lines	75	85	1	✓	✓	*
	Marker Assisted Selection to identify and tag molecular markers for taints of interest.	80	85	1	✓	✓	*
	Gene mapping and sequencing for desirable, agronomic traits and biotic and abiotic resistant gene	75	75	1	✓	✓	*
	Haploid breeding for development of homozygous inbred lines	60	70	2	✓	✓	-

4.4.4.3. Research Agenda/Thematic Area: Diseases and Pest Management

Problems/ constraints	Research Title/Key words	Beneficiary (%)	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
	Regular field monitoring to assess potential damage caused by insect-pests.	60	75	1	✓	✓	-
	Develop control method if any insect becomes serious pest	50	80	1	-	-	✓
	Survey and monitoring for new diseases and new races	65	75	1	✓	✓	✓
	Cultural, chemical and integrated control of major diseases, if any	65	75	2	-	-	✓
	Molecular characterization of disease pathogens	40	40	2	✓	✓	*

4.4.4.4. Research Agenda/Thematic Area: Crop Management

Problems/ constraints	Research Title/Key words	Beneficiary (%)	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
	Resource conservation technologies (RCTs) to manage heat, drought, salinity through straw retention and maintaining residual soil moisture.	70	80	1	✓	✓	✓
	Identify maize based profitable cropping pattern to sustain and improve soil fertility	65	75	1	✓	✓	✓
	Efficient irrigation scheduling	65	75	1	✓	✓	✓
	Develop and refine improved management packages for high yield goal	60	70	1	✓	✓	✓
	Develop planting method as relay crop with rice, especially for southern Bangladesh.	40	80	1	-	✓	✓
	Market chain development of maize for southern region	30	90	1	✓	✓	-

4.4.4.5. Research Agenda/Thematic Area: Farm Machinery

Problems/ constraints	Research Title/Key words	Beneficiary (%)	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
	Small scale farm machinery should be improved, (weeder, furrower etc.)	60	75	1	✓	✓	✓
	New entrepreneurship should be developed to enhance fabrication of machinery	65	75	1	✓	✓	-
	Development of low cost drier for maize, especially for kharif season.	50	70	1	-	✓	-

6. Research Agenda/Thematic Area: Seed Technology and Food Processing

Problems/ constraints	Research Title/Key words	Beneficiary (%)	Probability of success (%)	Priority Ranking	Research Tenure		
					Long	Med	Short
	Seed quality research (seed viability on storage, seed health, seedling vigour associated with seed vigour, seedling abnormality etc.	60	70		✓	✓	-
	Strengthening hybrid seed production	40	80		✓	✓	✓
	Blended food and bakery product development	40	100	1	-	✓	✓
	Screening for QPM with high carotene and minerals for human consumption.	60	70	1	✓	✓	✓

4.4.5 Opportunities

Vertical Expansion

At present there is huge yield gap between potential yield and farmers' average yield. Last year national average yield was 5.30 t/ha, while the demonstration average yield during last several years was 9.0-10.0 t/ha. Therefore, national average yield could be raised to 8.5 t/ha by adopting the modern production technologies.

The scope of horizontal expansion of maize in rabi season is limited due to heavy crop competition. Therefore, thrust should be given to popularize maize in early kharif seasons after vegetables, mustard, potato, lentils etc.

Horizontal Expansion

There is some scope of expanding maize in the southern part of Bangladesh and hilly areas.

Therefore, maize could be introduced in part of the areas with limited light irrigation or with residual soil moisture. In that case, high yielding disease resistant varieties well adapted to the stress situations like heat, drought, salinity, etc. will be required in future.

4.4.6 Conclusion and Recommendations

Bangladesh is a densely populated country and its cultivable land is shrinking but food demand (rice & wheat) is increasing every year. Therefore, it is important to produce more food per unit area. Among cereals only maize has got the highest yielding property. Bangladesh has unique opportunity to increase maize production. Because firstly, it is already familiar crop for its high yield potential, secondly about 100% area is covered with hybrids and thirdly it may be cultivated in both the seasons. Now steps should be taken to change the food habit of people as has been done during early seventies for wheat.

Effort should be made to expand its cultivation in southern belt, Sylhet regions etc. where lands remain fallow after harvest of aman rice and for these areas planting technologies (dibbling) and subsequent cultural method should be developed to harvest a moderate yield. Effort should also be made to increase maize

cultivation in early kharif season (early February planting) after harvest of early rabi crops like potato, vegetables, mustard, lentils etc. especially in the northern districts.

For research special emphasis should be given on biotechnology where

- Biotechnology and quality laboratories should be developed to facilitate future research along with human resource development.
- Collaborative research work with CIMMYT in special fields like breeding varieties for QPM, white grain maize for human consumption, water logging, drought, salinity, heat tolerance, etc.

4.5 Sorghum

Sorghum is a cereal crop which is a staple crop for many African countries as well as for some parts of India. It is grown in the harsh condition of semi-arid tropics where rainfall is scanty. Bangladesh is going to face climate change effect in future, especially in kharif season i.e. temperature will go up, drought condition will persist with greater intensity. The traditional crops are suspected to be affected. To face the challenge we should prepare ourselves from now. One of the strategies to meet climate change effect is to introduce new crops.

One such crop could be sorghum. Because it is a very hardy crop which can be grown under rainfed condition with less inputs. It has high yield potential. Moreover an International Centre, ICRISAT is working on it and hybrids are already available at ICRISAT for testing in our marginal and *char* lands. We can get technical as well as materialistic (genetic resources) support from ICRISAT to develop our program. This crop can be used to supplement maize for feed, food and fodder. BARI should initiate the variety development program soon in collaboration with ICRISAT to identify suitable variety for target areas.

4.6 Millets and Barley

Millets (Proso millet, Finger millet and Foxtail millet) and Barley were traditional crops of Bangladesh especially for rainfed marginal lands. But with the expansion of irrigation facilities and introduction

of more profitable crops millets and barley have almost been replaced. However, Foxtail millet is still cultivated in some small areas (char lands) of northern districts, Jamalpur and Comilla regions. BARI already released two varieties but these have not been extended to farmers yet. Steps should be taken to spread these varieties among the farmers. Simultaneously scientists should make inventory of the conserved viable germplasm in the Gene bank of BARI and then collect rest of the germplasms from the area from where it has not been collected yet. Steps should also be taken to collect germplasms of this crop from abroad and select better varieties suitable for Bangladesh.

In Barley already 6 varieties have been released by BARI. But none of these has been taken up by farmers. It is reported that barley is a saline tolerant crop so these varieties should be screened in the southern Bangladesh and try to extend them if found suitable. More germplasm may be obtained from ICARDA and may be screened them in saline areas to develop saline tolerant varieties. Side by side farmers should be trained on processing of grain, food & feed preparation etc. to popularize this crop in southern Bangladesh.

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Regional Workshop Feedback

Crops	Recommendations	Regional Workshop at			
		Bogra	Chittagong	Barisal	Mymensingh
Wheat	1. Salinity tolerant wheat variety	-	✓	-	-
	2. Heat tolerant short duration wheat variety	✓	✓	✓	-
	3. Late Planning wheat variety	✓	-	-	-
	4. Identify causes of wheat yield reduction	✓	-	-	-
	5. Nutritionally improved food crops	-	-	-	✓
Jute	1. Retting problem of Jute	-	-	✓	-
	2. Dearth of quality seed supply	-	-	✓	-
	3. Require short duration Jute variety	-	-	✓	-
	4. Need quality seed protection technology	✓	-	-	-
Sugarcane	Sugarcane research should be strengthened	-	-	✓	-
Maize	Lack of marketing facility of maize	-	-	✓	-

Comments from Central Workshop (held at BARC on 08-03-2010)

1. November to December Planting: Late planting to be in-built within the system of cropping.
2. Strengthening of hybridization program (more F1 generation) to get importance.
3. Rodent problem in southern belt in wheat in particular. How to address?
4. System Approach issue: To be in the recommendation part.
5. Millet (specially Foxtail one) & Barley to be considered as well.
6. International Collaboration in particular with the CGIAR institutions
7. In all cases wherever available BBS data to be used for others, source to be quoted.

Note: All the comments have been addressed in the relevant sections of this report

Major outcomes and outputs

The major outcomes are –

- The general problems related to crop production were identified from the literatures;
- Government policy on priority areas for research and development for food security, income generation and poverty reduction were analysed for research priority setting of each crop;
- The production trend and major constraints (biotic, abiotic and social) to production of each crop (wheat, maize, sugarcane & jute) were identified;
- The research progress so far made on these crops are summarized. The future demand of these commodities was estimated.

The major outputs are –

- The research priority for each crop has been set. The priority 1 problems can be addressed first followed by others later. This will guide the scientists, administrators to take up research programs, international linkage and develop HRD in future.

- The opportunities and niches for increasing production of the crops have been identified which will help the planners in taking up development program in future.

Conclusion and Recommendations

Priority research areas have been identified for sugarcane, jute, wheat, maize and sorghum based on the constraints and need of the country. Research thrust should be given, especially, on varietal improvement, disease and pest monitoring and management, abiotic stresses like drought and water logging management and crop diversification and cropping systems based research instead of segregated commodity research. Biotechnological research has progressing fast in other countries but we are lagging behind. To keep pace and to harvest benefits of this emerging branch of science it is important to give serious thought and thrust to augment research on this subject. Almost all the institutes have created some facilities for biotechnological research but these are not complete. Moreover, human resources have not been developed accordingly. Therefore it is recommended that all the facilities and man power on biotechnology within an institute should be pooled together and need based human resources should be developed and retained. Restructuring of scientific staff of the institutes is also necessary. The research budget should be increased from currently 0.22% to at least 0.5% of AGDP by 2030. Steps should also be taken to shift the food habit from rice to maize to meet the increasing demand in future.

Terms of Reference (ToR) of the Group Leader

1. Consultation and review of the documents related to agriculture and rural development. These are, but not limited to the followings. To accomplish the task the team may need to visit the concerned institutes.
 - Planning Commission Reports on five year plan, annual budgetary documents etc.
 - National Agriculture Policy
 - Poverty Reduction Strategy of the GoB
 - World Bank document on revitalizing agriculture and related others
 - Agricultural sector review /Actionable policy briefs of the FAO
 - Reports of the DFID, DANIDA and others on the performance of the agriculture sector in Bangladesh
 - National Food policy
 - National land use policy
 - National livestock Policy
 - National Fisheries Policy
 - National Forestry Policy
 - Vision document –2020 of BARC and Strategic plan of 1996
 - Land, Soil and management of natural resources
 - Reports on Food Security, quality and Safety
 - Reports on MDG
 - Master Plan & Annual Reports of ARIs
 - Websites of various agencies

(Source: BARC Library, P&E Division, BARC, Concerned Institutes, Websites of the concerned Ministry/Organization)

- 2) Through collection and collation of the information as stated in Sl.-1, work out the countries situation/issues by the sub-sector/area (12 nos.) of agriculture. These are:
 1. Rice
 2. Cereals other than Rice, Sugarcane and Jute
 3. Horticultural crops(Potato, Fruits, Vegetables, Spices including Flowers
 4. Pulses and Oilseeds
 5. Soil and fertility management

6. Forestry
 7. Livestock
 8. Fisheries
 9. Agricultural mechanization and water management
 10. ICT in agriculture
 11. Agricultural economics, marketing and supply chain development
 12. Technology development, agro-processing post-harvest technology, food quality and human nutrition.
- 3) Sub-sectoral studies are expected to be in-depth and detailed in nature. This to cover all component's current trend in production, demand-supply and gap, opportunities, problems and constraints, required technological interventions and their analysis in the country's context. By the process determine the priority need of the concerned sector/area by the year 2030 and beyond.
- 4) Population dynamics, reduction in land resource base and degradation, issues pertaining to climate change & sea level rise (SLR), economics of commodity and non-commodity related activities, income growth rate etc. all these to be taken into account in formulating the research priority.
- 5) Undertake other related tasks as may be deemed necessary or evolved while performing this assignment
- 6) Draft report of the teams to be presented in the workshops to be organized by the Planning & Evaluation Division of BARC at a suitable dates.
- 7) Draft final report incorporating the comments/opinion obtained from the workshops, different agencies/individuals to be submitted within 2 (Two) months from the date of assignment to the MD (P&E), Bangladesh Agriculture Research Council, Dhaka.

Annexure-III

Sub-sectoral Studies: List of Group Leaders and Member-Secretaries

Sl. No.	Sector/ Sub-sector	Areas to be covered (but not limited to)	Group Leader	Member-Secretary
1.	Cereals: Rice	Improvement of Rice varieties, Disease and Pest Management, Crop Adaptation to Climate Change, Biotechnology, Coastal Agriculture, Drought, Management, etc.	Dr. Md. Nasir Uddin, Ex-Director (Research), BRRI.	Dr. Mian Sayeed Hassan, PSO (Crops), BARC
2.	Non-Rice Cereals, Sugarcane, and Jute	Cereal Crops Improvement, Disease and Pest Management Crop Adaptation to Climate Change, Biotechnology, Coastal Agriculture, Drought, Management, etc.	Dr. M. Motiur Rahman, Ex-Director general, BARI	Dr. Md. Rafiqul Islam Mondal CSO (Crops), BARC.
3.	Horticultural Crops: Fruits, Vegetables, Spices, Flowers and Potato	Crops Improvement, Disease and Pest Management Crop Adaptation to Climate Change, Biotechnology, Coastal Agriculture, Propagation Technique, Hill Agriculture, etc.	Prof. Dr. Md. Abdus Siddique Dept. of Horticulture, BAU, Mymensingh	Dr. Abul Kalam, Azad CSO (Crops), BARC
4.	Pulses and Oil Crops	Crops Improvement, Disease and Pest Management Crop Adaptation to Climate Change, Biotechnology, Coastal Agriculture, Drought, Management, etc.	Prof. Dr. Md. Lutfur Rahman Dept. of Genetics and Plant Breeding, BAU, Mymensingh	Dr. Md. Aziz Zilani Chowdhury, PSO (Crops), BARC
5.	Land and Soil Resource Management	Soil Quality, Nutrient Status, Soil Health, Land Management & Degradation, Fertilizer Use Efficiency, Coastal Soil Management, etc.	Prof. Dr. Md. Jahiruddin Dept. of Soil Science, BAU, Mymensingh	Dr. M. A. Satter, CSO (Soils), BARC
6.	Forestry	Nursery Management, Disease and Pest Management, Agro-forestry, Climate Change, Afforestation in hilly and Coastal regions,	Mr. Fariduddin Ahmed, Executive Director, Arannyak Foundation, Banani, Dhaka	Dr. Mohammad Shahjahan, CSO (Forestry), BARC

Sl. No.	Sector/ Sub-sector	Areas to be covered (but not limited to)	Group Leader	Member-Secretary
		Medicinal Plants, etc.		
7.	Livestock	Epidemiology & Surveillance of diseases, Developments of Vaccines, Zoonotic diseases, Breed development and testing, Conservation of endangered species, Feed, Nutrition & Marine Fishery, Aquatic Pollution, Conservation of endangered species, etc.	Prof. Dr. M. M. Tarek, Former Professor, Department of Animal Nutrition, BAU, Mymensingh	Dr. Shah Md. Ziqrul Haq Chowdhury, CSO (Livestock), BARC
8.	Fisheries	Integrated farming, Intensification of fish culture & management technologies, Quality feed development, Fresh water & Marine Fishery, Aquatic Pollution, Conservation of endangered species, etc.	Dr. Khabir Ahmed, Former Executive Chairman, BARC	Dr. Md. Kabir Ikramul Haque, CSO (Livestock), BARC
9.	Irrigation & Water Management, Farm Machinery and Post-harvest Technology (Engineering Aspects)	Design & Development of low-cost farm machineries, Post-harvest Equipment, Water Management/Efficiency, Water quality, etc.	Prof. Dr. A T M Ziauddin, Dept. of FPM BAU, Mymensingh	Dr. Sultan Ahmed, CSO (Agril. Engg), BARC
10.	ICT and Disaster Management in Agriculture	Agricultural Databases & Knowledge Management, Use of GIS & Remote Sensing, Use of ICT in Vulnerable Environmental Monitoring etc.	Dr. SK. Ghulam Hussain, Member-Director, BARC	Mr. Md. Abeed Hossain Chowdhury, Director (Computer), BARC
11.	Agricultural Economics, Marketing and Supply Chain Development	Yield gap minimization, Profitability, Return over investment, Economics of Irrigation and Water Management, Impact Assessment of different technologies and projects, Public Intervention, Agricultural Price Policy & farm support, Land use	Dr. Md. Abul Quasem, Former Senior Research Fellow, BIDS	Dr. Fauzia Yasmin, PSO (AERS), BARC

Sl. No.	Sector/ Sub-sector	Areas to be covered (but not limited to)	Group Leader	Member-Secretary
		and Land resource management etc.		
12.	Food Availability and Consumption, Post-harvest Losses, Agro-processing Technology, Food Safety and Human Nutrition	Agri-business & Agro-processing, Post-harvest Handling, Food Adulteration, etc.	Mr. Md. Abul Quddus, Former Director General, BARD & WFP Adviser, Dhaka	Dr. M. Moslem Uddin Mia, Director (Nutrition), BARC

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